The Blast Furnace and Steel Plant

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UNIVERSITY OF MICHIGAN

The Blast Furnace and Steel Plant

American Iron and Steel Institute Meeting

Fourteenth General Meeting Held at New York, Featured With Speeches by Gary, Schwab and Replogle—Technical Papers Represent Valuable Contributions to the Iron and Steel Industry.

Confident that the industrial needs of the war would be met by the steel industry, and realization of the fact that practically the entire steel production for the next year at least would be used by the government, was the keynote of the fourteenth general meeting of the American Iron and Steel Institute, held at the Waldorf-Astoria, New York, March 31. The papers read at the technical session were of unusual interest in that they were timely and contributed information of considerable value in meeting the war production problems of the steel industry. From a standpoint of the technical papers read the meeting was one of the most important held during the past few years. The opening address, delivered by President Elbert H. Gary, and the speeches by Charles M. Schwab and J. Leonard Replogle at the banquet held in the evening, were the chief features of the meeting according to the enthusiastic reception which the 1,100 members and guests accorded the patriotic expressions.

Opening Address.

In opening the meeting, Judge Gary reviewed the earlier days of the institute, recalling the first meeting in 1910 at which time representatives from the iron and steel industry of all steel producing countries were present, and mentioned the progress and growth of the institute from its earlier days, when the membership was only about 200, until the present time.

In discussing the war and the relationship of the steel industry to the supreme struggle, the judge said:

"If we win this war, it will not matter much to us in dollars and cents—to us who are interested in the steel and iron output. And if we lose the war it will not matter much whether we have anything or not. The outlook is good. We have a steady customer and one who is able to pay as he goes. There is no occasion for gloom. I have no patience with a pessimist; we want to have a man in our business who sees the silver lining through the cloud and who is willing to stand up and fight it out.

"I believe we will win this war. Why? First, we are right; we seek no conquest from any nation. We have no disposition even to punish the evildoers beyond the bounds of demanding our rights. That we shall do, and we shall get those rights. When history comes to be written in future years in a fair and unbiased way the men who do the fighting behind those in the trenches and whose power is most felt in determining the war will be acclaimed as the steel and iron producers of America."

Judge Gary said all Washington now believes in the sincerity of purpose which actuates the steel and iron producers in their relation to the war.

"There is no telling," he said, "what will be our relations with the government in the future, for it not infrequently happens that a government official, like others, is incompetent. I recall the dark days of 1907 when we did not know where we stood with the government, but I am happy to say to-day that our general committee, working under the direction of the Secretary of War and the Secretary of the Navy, has been able to get fair decisions. Our unselfish attitude is appreciated in Washington.

"When we first entered the war one heard predictions everywhere that the government would take over the steel industry. Indeed, even now we must not expect too much liberality, too much concession. We must make our great interest subserve the government patriotically, or we must expect drastic measures. However, there are no indications of interfernce now, and I am satisfied that our industry can be placed at the disposal of the government and at the same time be protected for the common good of the nation as we are now operating."

Technical Session.

The program of the technical session held Friday morning and afternoon was as follows:

"Conservation of Ferro-Manganese," by C. R. Ellicott, Bethlehem Steel Corporation, South Bethlehem, Pa.
Discussion by George B. Waterhouse, metallurgical engineer, Lackawanna Steel Company, Buffalo, N. Y.; A. N. Diehl, assistant to president, Carnegie Steel Company, Pittsburgh, Pa.; Dr. J. W. Richards, professor of metallurgy, Lehigh University, Easton, Pa.

"The Design of the Modern Blast Furnace Stack," by J. G. West, Jr., general superintendent, blast furnaces, Jones & Laughlin Steel Company, Pittsburgh, Pa.
  Discussions by George L. Collord, Shenango Furnace Company, Sharpsville, Pa.; J. S. Frazer, Pittsburgh Steel Company, Pittsburgh, Pa.
"Relation of the Trade Papers to the Iron and Steel Industry," by Bertram S. Stephenson.
  Discussions by James R. Mills, Carnegie Steel Company, Cleveland, O.; A. O. Backert, Penton Publishing Company, Cleveland, O.
"The Electric Steel Plant at South Chicago," by T. W. Robinson, vice president, Illinois Steel Company, Chicago, Ill.
  Discussions by Dr. Henry M. Howe, Bedford Hills, New York; John A. Mathews, president, Halcomb Steel Company, Syracuse, N. Y.
"Effect of Phosphorus in Soft Acid and Basic Open Hearth Steels," by J. S. Unger, manager, central research bureau, Carnegie Steel Company, Pittsburgh, Pa.
  Discussion later by Bradley Stoughton, consulting metallurgical engineer, New York City.
"The Modern By-Product Coke Oven and Its By-Products," by W. H. Blauvelt, consulting engineer, Semet-Solvay Company, Syracuse, N. Y.
  Discussion by William A. Forbes, chairman, benzol committee, United States Steel Corporation, New York.

The papers read by Messrs. Ellicott, Stephenson, Robinson, Unger, and Blauvelt appear in this issue of THE BLAST FURNACE AND STEEL PLANT. The paper read by J. G. West, Jr., will appear in an early issue The second installment of the paper read by J. S. Unger will be published in the July issue.

Banquet.

The banquet in the evening was one of the largest ever held in the Waldorf-Astoria. Charles M. Schwab in responding to a welcome which was probably never given to any member of the institute so enthusiastically before, discussed the shipbuilding program and said in part:

"During the month of May the United States produced—not launched, but put into commission, ready for service—250,000 deadweight tons. And I am sure the month of May is going to be the least productive. I have enlisted the support of every industry in the shipbuilding or accessory line that is possible at this date; but that is not enough. During the past week we have contracted for new works aggregating $200,000,000 or $250,000,000 that will increase the shipbuilding capacity of the United States by at least 3,000,000 tons a year; and we will double that if necessary. We shall produce during this year 400,000 or 500,000 tons on the Great Lakes alone; but I think that is not enough, and in the coming year we can expect at least 1,000,000 tons from the Great Lakes.

"Last January there were 60,000 workers in the shipyards of the country. To-day there are 350,000, an danother 350,000 in the engine, boiler and accessory works.

"I am not vain enough to believe that any individual is a very great factor in so vast an undertaking. What is necessary is the united effort of everybody. Many people acquainted with affairs at Washington are prone to criticise what has been done. I was of the same mind at one time, but in my opinion the work done at Washington by Mr. Hurley, Mr. Piez, Goethals and the men who have been at this job has been magnificent. When the war started practically every shipyard in the country was taken up by the Navy. Every shipyard for the Emergency Fleet Corporation had to be created. I have already examined 60 or 70 per cent of the shipbuilding capacity of the United States, and I want to say that the work has been magnificently accomplished.

"But I don't believe we at Washington are a very great factor after all. The men who have the real responsibility are those in direct charge of the shipbuilding yards and the accessories. We can do little more than grease the wheels of progress. But the task and the responsibility is on the men in the shipyards; and not only the managers but down through the superintendents and foremen to the workers themselves. And only by their working as a unit can the result be accomplished. Don't think we are not accomplishing anything, for we are. We have started the shipbuilding program at a pace that cannot be stopped.

"I am proud of the steel industry. I feel confident that the steel industry will give us this year and next all the steel we need for carrying out the program. There is no industry anywhere that has so willingly and nobly and enthusiastically done its work for the country."

Mr. Replogle said that the direct and indirect necessities of the United States government would require all that the steel mills could produce for this year at least.

"We have been giving a good deal of attention to the question of essential and non-essential industries," he said. "I was rather surprised to find that the corset industry uses 15,000 to 20,000 tons of high-grade steel annually, and they claim that this is a necessity. All industries are essential from some standpoint, that of the owner if no other. We have preferred to go about it the other way and make a list of the more essential. How necessary this is you will see from the fact that we have unfilled orders on iron and steel manufacturers for the United States and the Allied governments for 16,800,000 tons. The burdens of the Allies are going to be much greater; the railroads will need many more rails, and Mr. Schwab's program next year will be double that of this year."

At the afternoon session of the institute H. H. Wheaton, representing Franklin K. Lane, Secretary of the Interior, addressed the members concerning an enterprise for the Americanization of industry in this country by teaching the English language in all the great centers of activity to workers of foreign birth.

A bill is to be introduced in the Senate, he said, by Senator Hoke Smith, of Georgia, appropriating $5,000,000 to be expended for the hire of teachers and defraying other expenses for the instruction of thousands of laborers who cannot speak English. The matter was referred to the executive committee with power to act.

Selecting Suitable Refractory Material

Considering Refractory Material to Withstand Fusion Within the Walls of a Blast Furnace or Other Furnaces—Determining Factors—Defects Encountered in Manufacture of Fire Brick.

By **J. W. HAULMAN.**

The selection of suitable refractory material to meet the existing conditions, i. e., to withstand fusion within the walls of a blast furnace or other furnaces or vessels which are subjected to the action of solids, liquids and gases that are employed in connection with the manufacture of iron or steel, is often a very difficult proposition to be met.

The tendency of a blast furnace charge to work on its walls necessitates the most careful selection of refractory material. The tendency to destroy brickwork especially around the tuyere breast which comprises that part of the hearth which extends from the bottom of the bosh to the top of the hearth jacket, is caused by the combustion of coke and the strong blast pressure in this part of the furnace. The temperature at the end of the tuyeres will reach from 3,200 to 3,400 deg. F. and may be as equally high for considerable distance around it, as the nose of the tuyere extends considerable distance beyond the face of the firebrick, the combustion temperature will nearly reach a maximum at the face of the brick which may be sufficient to soften the brick so that it becomes plastic or will flow under pressure.

The high velocity of the blast against the coke in the hearth will also cause an erosion in the lower part of the breast, the accumulating slag in the hearth will attack the brickwork, although the slag rarely comes within a foot of the tuyeres, it very often appears to be lying directly in front of the tuyeres when the cinder cannot be drawn from the cinder notch below. This accumulation of slag will cause a slagging of the brickwork and will have a tendency to thin the walls.

Serious breakouts frequently occur at the hearth, especially with increasing tonnage and fast driving and nearly always cause bad messes and delays. When breakouts occur through the hearth jacket they are caused mainly by erosion of the hearth walls by the blast. The chemical action of the slag and iron and the mechanical action of the iron and slag attacking the brickwork. The cutting out of the hearth walls is greatly increased by the action of currents of gas caused from combustion and the blast directly after a cast when the cinder and the iron is low in the hearth, although the temperature may be comparatively lower. The wearing away of the hearth bottom is usually slow. It may be six or eight weeks after the blowing in of a furnace before it becomes apparent. When a furnace is working hot at the bottom, the hearth deepens and when it is working cold, it naturally fills up. If the brickwork is poorly laid the deepening may progress through the entire run.

The composition of blast furnace slag is usually acid. A thin slag will attack brickwork much more rapidly than a viscous aluminous slag. A thick slag will have a tendency to adhere to the walls and fill the joints of the brickwork, while a fluid slag will drain from the walls at each cast and flush and upon rising it will again attack the exposed surface and constantly enlarge the joints. The chemical action of the iron and the mechanical effect of the weight will also have a tendency to increase the erosion of firebrick. An iron high in manganese will attack a lining more so than silicon, as the silicon goes off in the iron, whereas the manganese oxide will react with additional silica to form a manganese silicate.

The above facts are cited especially for the purpose of bringing to our minds the destructive effects of the charges within and to bring out one point essential in such linings, and that is the manufacture and quality of material used for such linings. The selection of clay and the application and selection of firebrick is of the utmost importance, and careful study must be made so as to make the proper selection of a material to meet the conditions to be encountered. A decision must be made as to whether an acid, basic or neutral refractory is desired, and it must be determined which is the best refractory under the conditions to be met. Many defects are encountered in the manufacture of firebrick, the melting point of which will not always insure its value in refractoriness. It is often found when one firebrick may have a lower melting point than another and is said to be less refractory, but in actual use the one with the low melting point will last longer than the one with the higher.

Modern blast furnace practice with closed tops, skip hoists, revolving tops, and high pressure blast makes it essential to use the best blast furnace brick that can be obtained, and selection must be made to suit the iron manufactured, whether basic or Bessemer. For an ordinary Bessemer iron, one might suggest that the brick used in the hearth and bosh be made of a fireclay mixture of approximately 80 to 85 per cent flint clay and 15 to 20 per cent plastic clay. The best results will be obtained when the flint clay is ground rather coarse, and only enough plastic clay used in the mixture to bind together the more refractory clay. Such brick should be burned in a kiln at a temperature of not less than 2,800 to 3,000 deg. F. in order to decrease shrinkage after they are placed in the furnace and subjected to high furnace temperature. If such brick are not properly burned in the kiln, cracks will undoubtedly occur in the blast furnace walls. These brick should be made under heavy pressure and should be true to shape and form. They should be carefully inspected and all soft burned brick and warped brick be rejected. The chemical analysis of a blast furnace brick should be as follows:

SiO_2	Al_2O_3	FeO	CaO	MgO	Alkalies
55%	40%	3%	Tr.	.50%	1.5%

In the selection of a clay, a rational analysis gives much information as to the behavior of a clay in shrinking and melting, which the ultimate analysis does not give. As for instance, a clay with an ultimate analysis showed SiO_2—55.2 per cent, Al_2O_3—31.0 per cent. The rational analysis showed:

Clay substance	76%
Quartz	14%
Feldspar	10%

The high percentage of feldspar shows that the 31 per cent alumina in the clay is not all silicate of alumina, but that 10 per cent is feldspar, which reduces the clay to 21 per cent alumina. The 10 per cent of feldspar being very fusible. The refractoriness of a clay always depends upon the proportion of these constituents which tend to lower the melting point of the clay. Ferric oxide also plays a very important part in lowering the refractoriness of clay, especially if the clay also contains carbonaceous matter.

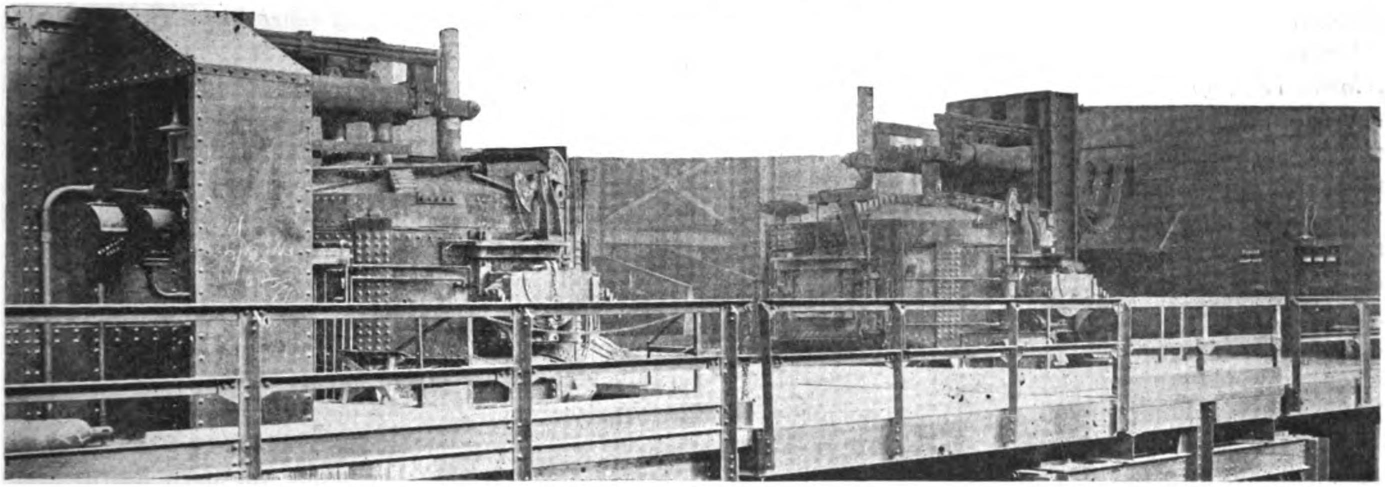
In practice it has been found that the texture of a brick governs to a certain degree its refractoriness. A brick made of a fine-grained clay is not as refractory as one made from a clay in which there is a large proportion of coarse particles. The composition of a brick may be correct, but often is poorly made. This will be shown as soon as the surface is worn off; the brick will begin to crumble and fall to pieces, whereas another brick will wear away slowly. The infusibility of firebrick at the highest working temperature and resistance to the penetration and erosive action of slags, etc., depends greatly on the care with which the bricks are made as well as their composition. When they are burned in a kiln at a very high temperature there are certain chemical changes which take place, and if the temperature is too intense the shrinkage will become too great and cracks will be formed and cause the brick to be porous; and if the temperature goes beyond a certain point they will be overburnt and also cause a porous and unsound brick, the structure of which has a great deal to do with the fusion point when it is exposed to furnace gases or slags; more especially slags for if a brick is porous the slag will penetrate the pores. This is encountered to a more or less degree when a low grade fireclay is used that is high in fluxing impurities. When a good fireclay is used low in fluxing impurities, the pores will close up slowly and the contraction will not be so rapid and a more uniform and sound brick will be obtained. It is impossible to attain a temperature in a kiln to reduce shrinkage to minimum, hence there will always be a certain amount of shrinkage in the brickwork lining.

Fireclay and silica bricks vary in the degree of expansion and contraction when exposed to heat, according to the composition of the materials out of which they are made. In furnace construction allowances must be made for expansion when building the linings, and most careful attention is always necessary when heating up the furnaces for the first time after being lined with either fireclay or silica brick. When the bricks expand very much they do not always come back in their original size and sometimes cracks in the brickwork or rifts in the joints are observed if the greatest of care has not been taken to liberate part of the framework which may enclose the lining.

Some experiments have been made to measure the amount of expansion and contraction that takes place in the silica and fireclay brick when exposed to heat. The results have been variable with different clays and no reliable data can be given, although in the case of a fireclay brick it is a safe estimate to say that clay when first subjected to heat its volume decreases, then it begins to lose water and its contraction can be estimated at approximately one-fifth of its linear measurement.

The laying of brickwork is a very important matter as is also the clay used in laying the brick. This clay should always be of the same composition as the brick laid with it, hence equal in refractoriness. The smallest amount possible should be used in the joints, so as to get as nearly as possible a brick-to-brick joint.

In the May, 1917, issue of THE BLAST FURNACE AND STEEL PLANT the author said in regard to fireclay: "In the manufacture of firebrick it must be burned in a kiln at a very high temperature, as there are certain chemical changes which take place. As the clay when heated shrinks so considerably that the form may be destroyed and cracks easily formed, such bricks are porous, but when subjected to an intense heat after a certain point has been reached a chemical change will take place which causes their grains to be bonded together. However, if the temperature becomes too great or goes past a certain point it will be overburned and cause a porous or unsound brick. This is invariably encountered in a low grade fireclay, but where a good fireclay is low in fluxing impurities, such as Fe_2O_3, the pores will close up slowly and the contraction will not be so rapid, and a more uniform and sound brick will be obtained. It is impossible to attain a temperature in a kiln to reduce this shrinkage to a minimum, hence there will be a certain amount of contraction in the brickwork lining."



The Triplex Electric Steel Process

Description of Electric Steel Process at South Chicago Supplemented With Data Covering Latest Developments Particularly Relative to Manufacture of Electric Steel in Large Quantities.

By T. W. ROBINSON,
Vice President, Illinois Steel Company.

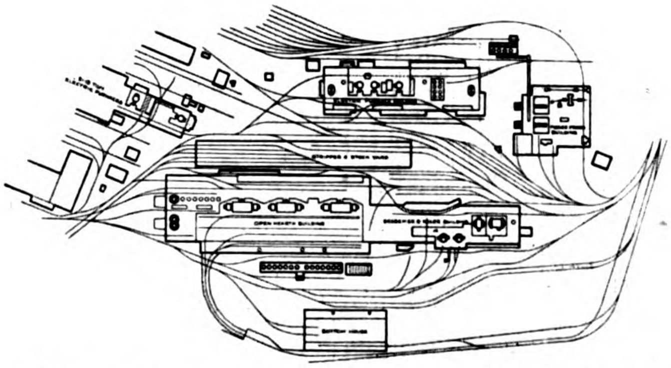
T. W. Robinson,
Vice President, Illinois Steel Company, Chicago,.

> *"When we realize the economies that have been commanded with the open hearth furnace during the last 20 years, it perhaps is not unreasonable to anticipate that much may be accomplished along similar lines with the electric furnace. There appears to be no reason why electric furnaces larger than those already installed cannot be built."*

It is a far cry from Benjamin Franklin expounding American democracy in the court of France to the maintenance of American ideals on the battle fields of Europe—yet the enlightening power of Franklin's statesmanship promises to pale into significance before the compelling force of the guns that are being produced through his genius in electrical discovery. Electric steel has played no unimportant part in the theater of war.

This paper has to do with the triplex process of producing electric steel as carried out at the South Chicago works of the Illinois Steel Company. In the following survey, it has been the aim to leave the description of physical features of plant largely to illustrations and drawings, and to confine process reference to its most salient points. The technicalities of general plant design and operation of the electric furnace have been ably presented before this institute by W. R. Walker, Dr. John A. Mathews, and others. The object of this paper will have been achieved if with a minimum of repetition, it supplements existing records with later developments, especially in connection with the manufacture of electric steel in relatively large quantities.

The development of electric steel at South Chicago was based upon the fundamental conception that the electric furnace was pre-eminently adapted to the manufacture of carbon and alloy steel of the highest quality; that it would be possible to produce electric steel in sufficiently large units to permit its use in heavy products; and that the increasing demand for high-grade steel would provide a sufficiently extensive



General layout of plant at South Chicago, showing arrangement of electric furnace building, forge shop, open hearth department and Bessemer and mixer building.

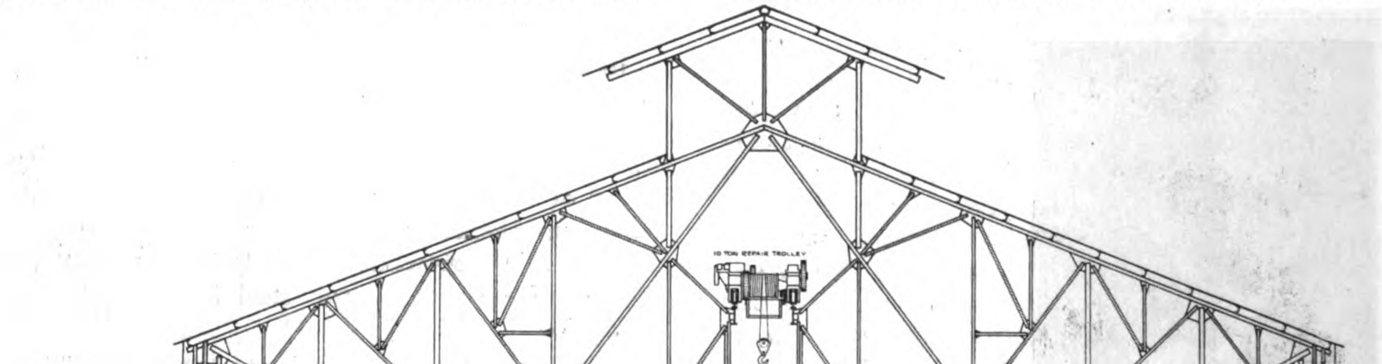
Paper read before May meeting of American Iron and Steel Institute.

market to make its manufacture commercially possible.

Under these promises, the Illinois Steel Company in May, 1909, installed its first electric steel furnace at the South Chicago works. At that time there were only two other electric furnaces in this country concerned with the manufacture of electric steel—one at the Halcomb Steel Company, Syracuse, N. Y., and the other at the Firth-Sterling Steel Company, McKeesport, Pa. The furnaces here and abroad were all small, running from a ton or less to five tons in capacity. Our installation consisted of a 15-ton basic-lined Heroult furnace with an electric equipment for three-phase, 25-cycle, and 110-volt current. The manufacture of electric steel was a new art, and ours was a new adaptation of a new art. As to the troubles we encountered, I may say, their name was "legion." Perseverance conquered, however ,and we soon had the satisfaction of producing a metal of unquestionably superior quality.

As the fundamental object was to demonstrate the opportunities of the new process in connection with heavy products, attention was early turned to the experimental manufacture of electric steel rails. Under the limitation of equipment, it was necessary to depart from standard rail practice to the extent of accumulating cold ingots and reheating them., The electric steel used was made from Bessemer blown metal. We advisedly felt our way in chemistry. Irregularities incident to incomplete equipment was unavoidable. In spite of pioneering difficulties, about 10,500 tons of electric steel rail were laid on 14 railroads throughout the country. The result of these rails indicated that electric and open hearth rails of like chemical composition had practically the same resistance to wear when the former were made under the conditions that existed at the time of their manufacture. The failure from breakage was almost negligible; there were no interior defects, and the test showed that the electric steel was considerably more ductile at low temperature than either the open hearth or the Bessemer steel.

In order to further determine the facts, a series of experiments were undertaken with a view of testing the ductility of rail steel at low temperatures. A refrigerating plant was erected adjacent to our regular drop-testing machine. About 900 pieces of electric, open hearth and Bessemer rails of various sections were tested at temperatures ranging from 70 deg. F. to 50 deg. below zero. These tests emphasized that in the case of all the steel there was a marked decrease



Cross-sections of electric furnace building.

in resistance to shock as the temperature lowered. Relatively speaking, however, the electric steel was distinctly more ductile than either the Bessemer or open hearth. The following summary from two electric and two open hearth heats of similar analysis involving 242 tests is typical of the general results obtained. The figures given in Tables B, C and D are average results. The chemical composition of the heats in question is as follows:

TABEL A.

	Car.	Mang.	Phos.	Sul.	Sil.
First electric heat......	.64	.60	.024	.019	.216
First open hearth heat.	.62	.71	.020	.040	.140
Second electric heat...	.73	.90	.022	.043	.256
Second open hearth heat	.72	.88	.035	.033	.200

TABLE B.

Average number of blows required to break the rails.

*Temperature	Electric	Open hearth	Comparison
+60° F.	3.48	3.64	O. H. 5% over Elec.
0° F.	4.41	3.82	Elec. 15% over O. H.
—30° F.	4.55	2.24	Elec. 103% over O. H.
—40° F.	3.31	2.03	Elec. 63% over O. H.

TABLE C.

*Temperature	Electric	Open hearth	Comparison
+60° F.	2.96″	3.36″	O. H. 14% over Elec.
0° F.	1.41″	1.23″	Elec. 15% over O. H.
—30° F.	1.46″	0.58″	Elec. 152% over O. H.
—40° F.	0.91″	0.43″	Elec. 112% over O. H.

TABLE D.

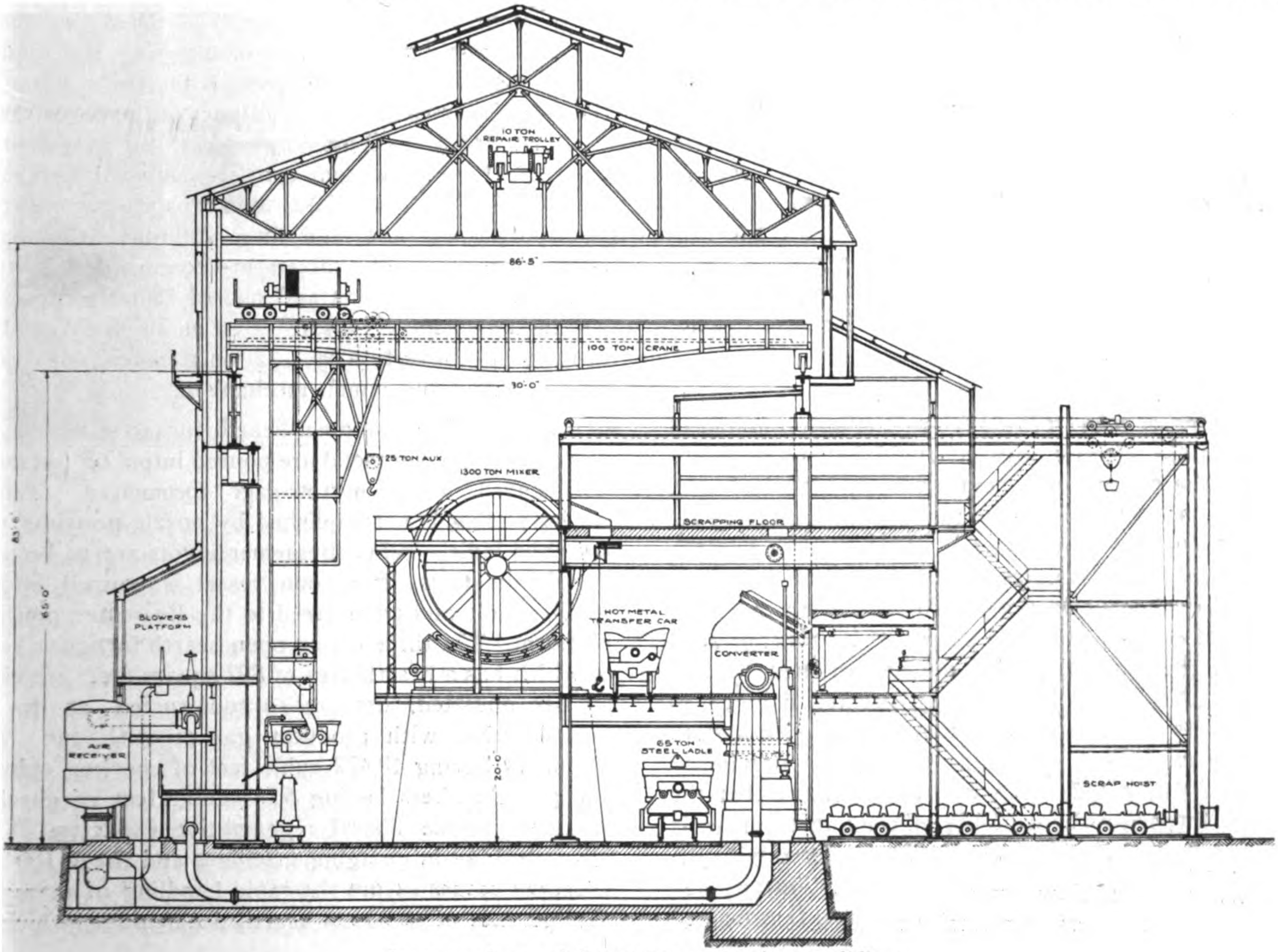
Elongation in 12 inches measured after last blow before the destruction.

*Temperature	Electric	Open hearth	Comparison
+60° F.	0.808″	0.929″	O. H. 15% over Elec.
0° F.	0.404″	0.397″	Elec. 2% over O. H.
—30° F.	0.420″	0.201″	Elec. 109% over O. H.
—40° F.	0.297″	0.141″	Elec. 111% over O. H.

* 60° F., 18 foot drop. 0° F. and below, 8 foot drop.

In all these tests the height of drop was kept comparative. At normal temperatures 18 feet was employed. At 0 F. and below, the steel weakened by the cold could not withstand so heavy a blow, and the drop was reduced to 8 feet. While it is self-evident that the number of heats involved in the above tables is entirely too small to permit the drawing of definite conclusions, the fact that the other drop tests and the result of the rails in track all pointed in the same direction warrants the belief that the resistance to dynamic force rapidly decreases with lower temperature in the case of both open hearth and electric steel, and that electric steel is tougher than open hearth steel at low temperatures.

During and after the period in which we were manufacturing electric steel rails, we were experimenting with such other heavy products as forgings, plates, axles and structural shapes. Not only had carbon steel been made in relatively large quantities in connection



Cross-sections of Bessemer and mixer building.

with these productions, but the field of alloy steel had been comprehensively entered. Expanding demand led to the introduction in July, 1916, of a second furnace similar to the original one in electrical equipment and capacity. This gave a combined capacity of about 4,500 tons of electric steel ingots per month.

By this time our experience had verified in a large measure the soundness of the views upon which our original electric furnace installation was predicated. We had demonstrated that it was possible to produce electric steel in relatively large units without the sacrifice of quality. The physical characteristics of the steel had proved to be admirably adapted for heavy products. There was a growing demand for a superior steel for general purposes, and the call for alloy steels was rapidly increasing in connection with the automobile and other industries. Extent of market was largely a question of price, and price logically was a matter of cost.

In the meantime an addition to our open hearth at South Works had become desirable, and in connection therewith the matter of increasing our electric steel capacity was taken under consideration. In studying this subject, we were naturally guided by our past experience. We had made electric steel by the melting of cold stock. We had refined in the electric furnace both molten blown Bessemer metal and molten open hearth metal. We also had made steel by the initial refining of Bessemer blown metal in the open hearth, supplemented by final refining in the electric furnace. Part of this work was experimental in character. None of it was done under ideal economic conditions. The cost of producing steel in the electric furnace was vitally influenced, of course, by the amount of power used, and this and other conversion items were in turn largely influenced by the tonnage produced. Manifestly nothing could be considered that would sacrifice quality for output without destroying the very essence and reason for the electric process.

As electricity is an expensive metallurgical fuel, the melting of cold stock or the preliminary refining of metal in the electric furnace could be accomplished only at the expense of a comparatively high fuel cost. Our original practice was to make electric steel by refining Bessemer blown metal. This process necessitated two distinct operations in the electric furnace, namely, dephosphorization by the use of an oxidizing slag, and deoxidization by means of a reducing slag. Steel of the highest quality can be produced by this practice, but there is obviously greater liability to irregularity in this method than when open hearth metal is used from which the phosphorus previously has been eliminated. It is well to remember that the electric furnace while a highly efficient instrument, is far from foolproof. Several years' experience with the use of Bessemer-blown metal in the stationary open hearth furnaces under the local conditions that existed had helped to demonstrate the advantages of the duplex process for producing open hearth steel. It likewise had been shown that electric steel could be most advantageously produced at South Chicago by the use of open hearth metal.

It was essential that the proposed plant should be so designed as to provide not only Bessemer metal for open hearth refining and open hearth metal for electric refining, but Bessemer ingots and open hearth ingots as well. Many new problems were involved. It was clear that for the simultaneous production of Bessemer, open hearth and electric steel, extreme elasticity of operation was fundamental if efficiency was to be attained. Close assembly of the various units was essential for rapid and economical practice. The sequence of operation had to be unobstructed. A supply of hot pig metal and preliminarily refined molten steel must be provided. The plant as finally designed, both in respect to its general plant location and its general details of construction, is shown in the illustration.

Inasmuch as this article deals specifically with electric steel, no attempt will be made to give a detailed description of the Bessemer and open hearth refining as carried out in the new plant at South Chicago. The metallurgy and physical manipulation present little that is novel, and the principles of the duplex process as such are well understood.

In respect to the plant, it will be noted that there are two main buildings; one comprising the duplex plant proper, and the other parallel thereto, containing the electric furnaces. As an adjunct to the latter, there was installed a 1,500-ton forge press. In its essential features, the duplex plant consists of two mixers, one of 1,300 tons and one of 300 tons capacity; two 25-ton acid-lined converters, and three 250-ton tilting open hearth furnaces. The mixers are commanded by two cranes, one of 100 tons and one of 75 tons capacity, and the mixer metal is transferred on an elevated platform to the converters by a 25-ton transfer ladle operated by cable and winch mechanism.

When used in the open hearth furnaces, two heats of Bessemer blown metal are poured into a 65-ton ladle commanded by a narrow-gage locomotive. Elimination of slag is accomplished by nozzle pouring into a second ladle. When Bessemer ingots are to be produced, the metal from one vessel is poured into a smaller ladle and transferred to the Bessemer pouring platform. The three tilting open hearth furnaces, each of which has a hearth area of 892 square feet, are electrically operated, and are so constructed as to be heated either with producer gas or with tar. Air chambers having 10,472 cubic feet of checker volume and gas chambers having 6,734 cubic feet of checker volume, provide liberal regenerative capacity. Two low-type 7½-ton charging machines and three 100-ton overhead cranes assure the rapid handling of material. The pit side of the open hearth department, which is generous in its dimensions, is served by two 175-ton cranes, and is provided with a 330-foot pouring platform capable of handling two sets of molds.

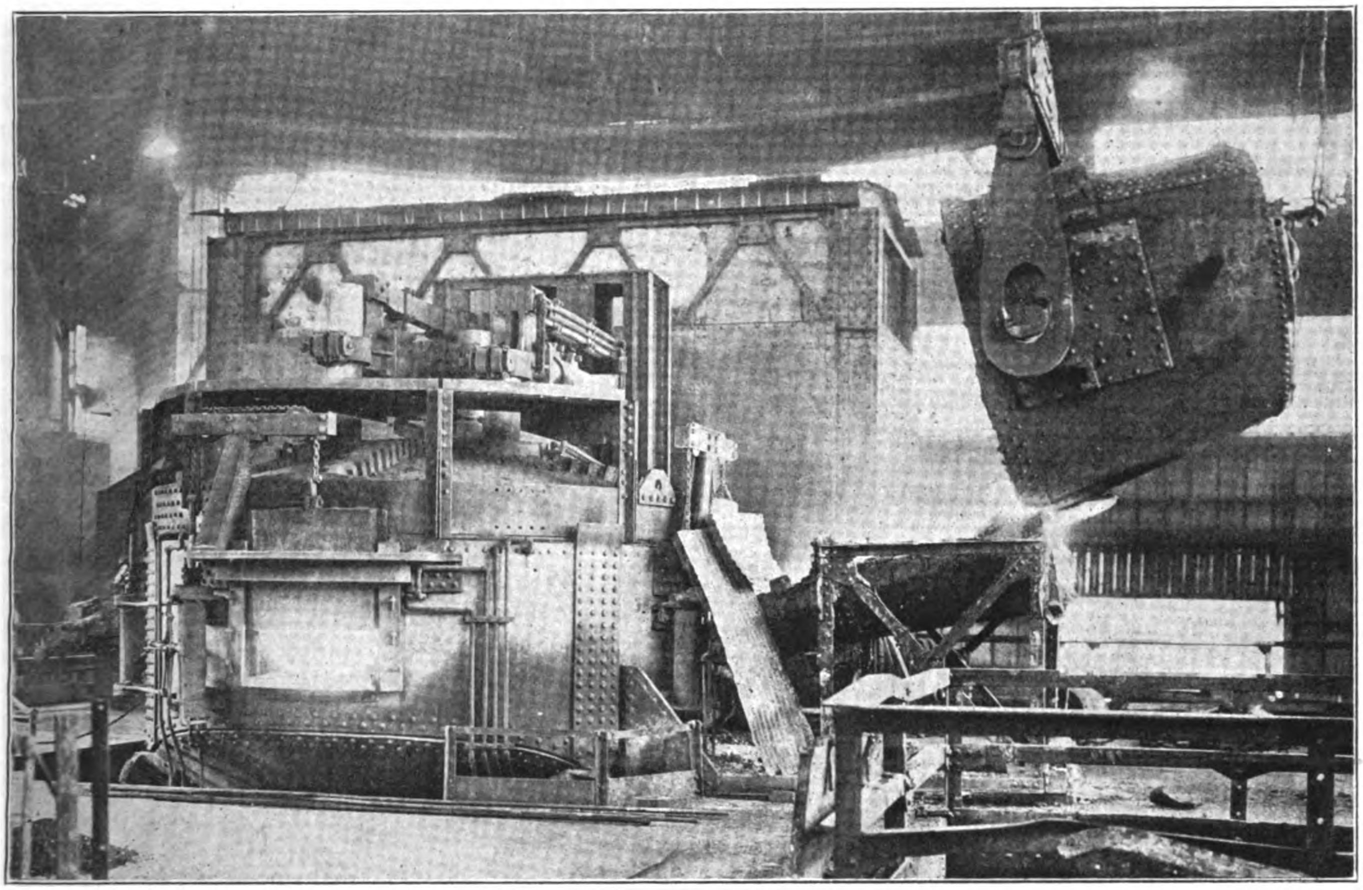
The Bessemer plant is designed for the ultimate addition of a third vessel. Its present capacity may be conservatively placed at 75,000 tons per month of blown metal, Bessemer ingots, or any desired combination of the two. The three tilting open hearth furnaces when operating on blown metal are rated at 65,000 to 75,000 tons per month. The elasticity of their operation is self-evident, and it is obvious that their actual tonnage is dependent upon the character of the charge used. At the present time two of these furnaces are running on open hearth material, with Bessemer blown metal as a base. The other furnace is operating on a nickel steel scrap charge with molten pig iron additions for further refining in the electric furnace.

In transferring open hearth metal to the electric furnaces, it is the aim to have the metal slightly lower in carbon and manganese than the specifications under which the electric steel is to be made. There is, of course, ofttimes a wide range in the specifications under which the electric furnaces are operating, involving high and low carbon and various alloy steels.

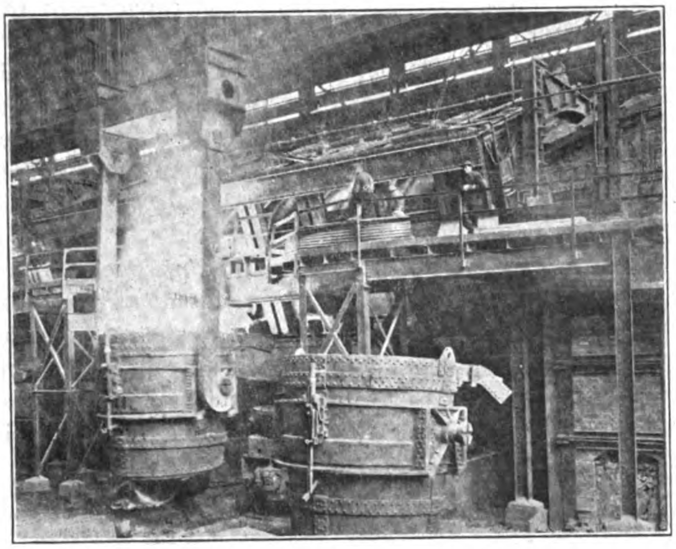
The new electric plant contains three 25-ton Heroult furnaces, each with an adjacent transformer building. The general design and dimensions are shown by the plan and cross-sectional views. The capacity of the plant naturally is somewhat dependent upon the character of the steel made, but may be placed approximately at 12,000 tons per month. This, with the output of the two old furnaces, gives a total electric steel capacity of 16,000 to 17,000 tons per month, and makes the South Chicago works the world's largest electric steel producing plant.

The advancement in the design and operation of electric furnaces has not necessitated any radical change in the original electrical scheme as a whole. Such improvements as have been made have been rather in the nature of refinement than essential change. In the case of the large electric furnace, it is more necessary than in the small furnace to consider the losses due to reactance in the electrical current. When we consider the relatively little power required by the original furnaces, it is evident that in the case of our larger furnaces which are equipped with transformers of 3,750 k.v.a. capacity, the question of power losses is an important one. In respect to the electric furnace load from the central station standpoint, it is interesting to note that with four furnaces operating on the triplex process, 24-hour load factors of 75 or 80 per cent are not unusual. This compares favorably with other forms of industrial load.

In our practice the furnaces ordinarily are operated with only a reducing slag, and care is taken at all



Pouring open hearth metal into large electric furnace.



Tapping one of the 200-ton tilting open hearth furnaces.

times to see that such conditions are obtained as will most thoroughly and quickly effect complete deoxidation. After the steel is thoroughly dead-melted and the reactions are complete as determined by the careful testing of the slag and metal, the current is reduced until a proper pouring temperature is obtained.

The pouring of steel from the electric furnace is subject at all times to the careful control of pyrometric observation. For the production of a satisfactory steel, a proper casting temperature is an important element in all processes, but with the electric furnace special care is needed, partially because of the high heats obtainable with the electric arc. Electric steel on account of its freedom from gases is specifically a dense steel, and in metal of this character the pipe tends to be exaggerated. It is our custom to teem all electric steel in inverted molds with refractory hot tops. As a result, little difficulty is encountered either with the piping as usually found in the ordinary ingot.

In connection with alloy steels, it is very necessary to guard against any condition that will unduly tend to unequal ingot strains, and special precautions are taken to avoid undue surface tension in the molds. We are now casting ingots weighing from 3,400 to 38,000 pounds, the uniform solidification of which is made the subject of the greatest care. Top pouring, box pouring and bottom pouring are resorted to, as the individual character of the steel best appears to warrant, and the entraining and inclusion of slag or other foreign matter is carefully guarded against.

To one familiar merely with the casting methods in vogue with ordinary open hearth or Bessemer steel, the pit practice incident to the proper manufacture of electric steel is something of a revelation. In the subsequent work to which the ingot is subjected, whether in the forge or in the rolling mill, special precautions are taken in the heating, in the reduction of the metal and in the cooling of the product. Ordinarily mill practice will by no means suffice if proper results are to be obtained, especially when alloy steels are concerned. Steel which may be innately of the highest quality when tapped in the ladle may readily retrograde or become unfit unless there is exercised extreme care in its later manipulation. Quality is peculiarly the sine qua non of electric steel, and the price of success is eternal vigilance.

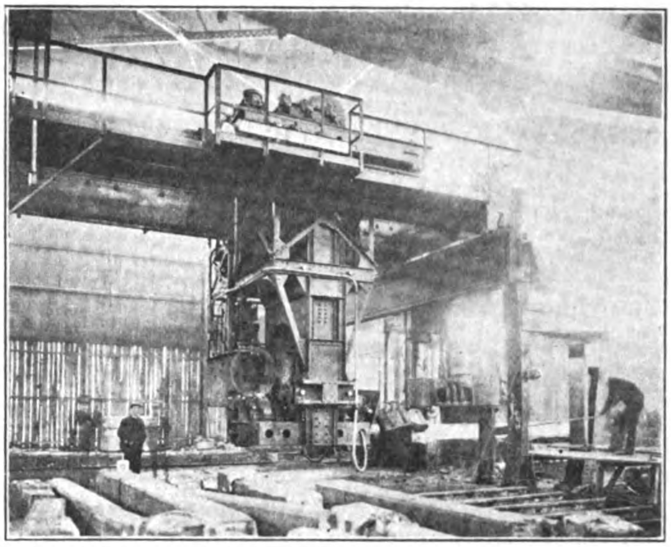
There is, of course, nothing occult nor mysterious in the electric method, although there is more or less misconception concerning the production of electric steel. The electric furnace, when used for the manufacture of steel may be likened to a large crucible heated from within instead of from without by the electric arc. It is capable of performing not only the functions of the open hearth, but very largely those of the crucible as well. Its superiority lies in the rare purity of the heat derived from the electric current and in the peculiar slag control that can be commanded in a neutral atmosphere. Both the Bessemer and the open hearth processes are distinct in their physical and metallurgical character. The electric process may likewise be considered as distinct when concerned with the manufacture of steel directly from cold metal. When, however, it is used to finish metal which previously has been made in the Bessemer or open hearth, it may be considered as supplementary to standard methods rather than as an independent process. Other than as manufactured in the smaller and perhaps more ephemeral installations, electric steel is to-day, and probably will be in the future, largely produced by a duplex or triplex process whereby, strictly speaking, steel is electrically refined rather than electrically made.

The manufacture of steel is far from being an exact science. It is an art founded upon scientific principles and to a degree subject to scientific control—but there is much in the metallurgy of steel that bespeaks ignorance instead of knowledge, uncertainty instead of definite determination. It logically follows that one should not be dogmatic in passing upon the respective qualities of steel made by different processes. As measured by customary chemical and physical standards, it is possible to show that steel made by the Bessemer process is at times equal in quality to that made by the open hearth, and steel made by the open hearth is equivalent to that made in the crucible. By the same token, it may not be difficult to show that steel made by the open hearth proces is as good as that made in the electric furnace. Certainly some of our laboratory results, upon which we ordinarily depend for metallurgical guidance and control, warrant such an assertion. But just here science, paradoxically speaking, proves unscientific, and the laboratory ofttimes does not square with the results in the field. We all know that irrespective of laboratory tests, the final verdict of result in service has already clearly established the superiority of open hearth steel as compared with Bessemer, and the superiority of crucible in its own particular field as compared with open hearth. In the last analysis, the characteristics of any metal must be determined by the composite testimony of practical experience. It perhaps may be argued that as so determined, the verdict in respect to steel made in the electric furnace is still an open one because of its comparative youth. Nevertheless, the result of 10 years' experience here and abroad strongly points to electric steel being in its natural qualities equal to crucible steel, and superior to the steel ordinarily made in the open hearth. As bearing upon this, the testimony of our honorary and honored member, Dr. H. M. Howe, as recorded in his classical "Metallurgy of Steel" is of interest. Dr. Howe states:

> It is not easy to see why crucible should be better than Bessemer and open hearth steel of like composition.* * * Whatever be the reason, there seems to be but little doubt that crucible steel is better than Bessemer and open hearth steel of like composition as actually made. * * * The belief in the superiority of crucible steel of like composition rests rather on general observation than on conclusive direct evidence, and it must be confessed that the quality of much of this evidence is not of the best. This, however, from the nature of the case is almost unavoidable, but the quantity of evidence goes far to make up for its quality.

It behooves one, therefore, to be conservative in his prognostication. Forty years ago this country produced but little over a half million tons of steel, 90 per cent of which was made by the Bessemer process. Last year we made 43,000,000 tons of steel, and to the open hearth 75 per cent is to be accredited. While our production of Bessemer steel has remained nearly stationary since 1906, when it reached its zenith with an output of 12,250,000 tons, the open hearth has rapidly forged ahead, and last year it accomplished over 32,000,000 tons.

The marvelous development in Bessemer steel was due both to its superiority for general purposes as compared with wrought iron and to its relative cheapness of production. The more recent expansion of open hearth is attributable not alone to changing ore conditions and to the lower cost incident to modern construction, but to the increasing demand for a higher quality of steel. The passing of the Bessemer plate and the Bessemer beam and channel was only a prelude to the replacement of the Bessemer rail by its open hearth rival. It is true that steel made by the Bessemer process is admirably adapted to certain products, and for many years to come will play an important part in the metallurgical economies of our nation, but the glory of the converter has definitely paled before the more enduring reliability of the open hearth. In the earlier stages of our steel manufacture tonnage as an essential element of cost was a domninant consideration. Neither the mill nor the consumer attempted more than a general differentiation as to the character of the product. It was largely a matter of quantity and price. Now quality stands first, and while tonnage has gone on apace, volume has become more and more subordinate to character of production.



Forge press and manipulator.

What does this increasing demand for higher quality portend for electric steel? How much is history to repeat itself in connection with the new process? It is clear that the lower the cost of production, the greater will be the field presented, and much will depend upon the ironmaster's ability to reduce the cost of electric refining to a minimum. When we realize the economies that have been commanded with the open hearth furnace during the last 20 years it perhaps is not unreasonable to anticipate that much may be accomplished along similar lines with the electric furnace. There appears to be no reason why electric furnaces larger than those already installed cannot be built. Cost should be inverse to tonnage, and high quality is not incompatible with large production.

If one is intelligently to read the future, he must take into consideration both statistics and psychology. The annual statistical report of the American Iron and Steel Institute first separately classified electric steel in 1909, with a production of 13,762 tons. Last year this country produced 234,000 tons, which is more steel than was made annually in all our open hearth furnaces 30 years ago. The output of electric steel this year undoubtedly will be much greater. We are now producing at the South Chicago plant at the rate of 140,000 tons per year, and we shall shortly be producing at the rate of 200,000 tons per year. Our country is growing rapidly, and the per capita consumption of steel is growing even more rapidly. In 1900, our population was approximately 76,000,000, and each of our inhabitants represented an annual consumption of 280 pounds of steel. In 1916, our population had reached 103,000,000, and our annual consumption of steel had increased nearly three-fold, to 820 pounds per capita. These figures do not include our exports of nearly 5,250,000 tons made that year.

The Conservation of Manganese

Modification of Standard Practice and Revision of Specifications Both in Raw Materials and Finished Products Suggested to Effect Conservation of Manganese.

By C. R. ELLICOTT,
Superintendent of furnaces and mills, Lehigh plant, Bethlehem Steel Company.

The effect of the war on the manganese supply for the steel production of America has taught us that our greatest industry is dependent in a large part upon the importation of manganese ores or manganese alloys.

In the past two years, material efforts have been made to increase the output of manganese ores and alloys within our own country, spurred on, perhaps, by the high price per unit of manganese in the ores. The effect of this effort has been felt, but the seriousness of the situation still remains. In the present and immediate future it is not only desirable and profitable to prospect for, and develop manganese and manganiferous iron ores, but it is our patriotic duty to the economical situation of the country to do all in our power to increase the domestic production of manganese alloys, and to conserve our available supply. There is no doubt, sufficient manganese ores and manganiferous material exists within our boundaries to meet our own requirements until normal conditions return; meanwhile, it will be necessary for a broad-minded spirit of national welfare to exist, first among the steel manufacturers, and second, between the manufacturers and the steel consumers.

It is not the object of this paper to say what shall or shall not be done. It is only to show with the information available, first the true manganese situation; second, to suggest from a manufacturer's point of view, possibilities of conservation and to request suggestions and criticisms which will produce a national saving of this important metal. If the situation is squarely faced, habit, hearsay and tradition thrown aside, a general modification of standard practice and intelligent revision of specifications, both as to raw materials and finished products, will effect considerable saving of manganese.

The Effect of Manganese.

The influence of manganese must be appreciated to its fullest extent in steel manufacturing, and equally important, its effects upon the finished product must not be overrated if any economical departure from our present standards is to be made.

Manganese is used in steel making for three distinct purposes:

1—In the melting operation it is of great advantage up to a certain percentage of the charge, as a deoxidizing agent for making ingots which can readily be rolled or forged with the minimum amount of scrap and defective material.

2—It is used in specified percentages to give desired physical results in the finished product, acting as an alloy.

3—It is added to obtain a specified percentage in the finished material, but not for the hot working qualities of the steel nor for desired physical properties which would necessarily be a function of manganese. It is added as a matter of accepted practice subscribed to by both producer and consumer without considering manganese conservation.

These three purposes are considered in detail as follows:

1—As a Deoxidizing Agent.

In the average open hearth practice .60 to .80 manganese is in the charge from the pig iron and scrap. All furnace reactions including decarbonizing and desiliconizing are oxidation processes. Some oxides are soluble in molten steel, and these, when the steel is near the point of solidification, will usually generate gas, thereby forming blow holes, which later appear as surface or internal defects in the finished product. In addition, oxides contribute to what is commonly known as "red shortness" or brittleness when hot. Manganese material in any form in the initial charge prevents the formation of soluble oxides in the steel, or reduces what might be formed during the period the steel is molten. In other words, if an appreciable percentage of residual manganese can be maintained in the open hearth furnace from the time the charge is melted until it is tapped, further additions of manganese can be eliminated in high carbon steels, and greatly reduced in lower carbon steels to produce the same ductility in rolling which would be expected from heats which were low in residual manganese and finished with high manganese recarburizing additions.

This practice will not reduce the total pounds of manganese added to a given ton of steel, but it will permit the use of a lower grade of manganiferous material available in this country to replace the higher grade material which in normal times has been imported.

2—Physical Properties.

The second use of manganese is to give special physical properties to the finished product, subdivided as follows:

(a) Steels used in the rolled, forged, cast or annealed condition.
(b) Steels heat treated.
(c) Special manganese steel containing 11 to 14 per cent manganese.

Paper read before May meeting of American Iron and Steel Institute, New York.

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Subdivision (a) contains by far the greatest tonnage of steel produced. The effect of manganese on the physical properties of these steels is to increase the elastic limit and tensile strength. In cases where this is the sole purpose of manganese additions, we suggest the use of other strengthening elements, preferably carbon.

Subdivision (b) consists of heat treated steels of normal manganese content. The effect of manganese is similar to nickel, except that its influence is not so marked. Its effect is to retard the transformation of austenite in cooling. The use of manganese for improving the physical properties of heat treated steels is not essential as this improvement can be obtained by other available elements. We would, therefore, suggest that where nickel can be substituted, the use of manganese be restricted, and in other cases where it plays no part in heat treated results, it be reduced to a point where its function is of forging or rolling importance alone.

Subdivision (c): Hadfields' manganese steel containing 11 to 14 per cent manganese is a special product with special physical properties due to the manganese content. No change in present practice for this steel can be made.

3—Specifications.

The other function of manganese is to fill specifications. There is no question but that many consumers specify a manganese content for no reason within their knowledge and for no special purpose. A large tonnage of the steel produced is made to both physical and chemical specifications. If only the physical qualities in forged, rolled, cast or heat treated products were specified, the manufacturer would be free to economize in manganese.

Manganese Requirements for Steel Manufacture.

The statistical record of steel products for 1917 has been delayed, but as the total product of 1917 was very close to that of 1916, the 1916 figures will be used.

We have classed the various grades of steel roughly according to manganese content usually specified. These classes are arranged in the order of their tonnage importance.

Class 1—Low carbon steels below .25 carbon, such as structural steel shapes and plates for bridges, buildings, etc., boiler and firebox steel, plates, shapes and bars for railway cars; low carbon splice bars, forging steels, rivets, pipe, tubes, tin plate, bolts, sheets, spikes, tie plates, wire rods, merchant bars, etc.

Class 2—Medium carbon steels .25 to .80 and high manganese steels including Bessemer and open hearth carbon steel rails, quenched high carbon splice bars, nickel, structural, rivet, silico-manganese spring steel; chrome-vanadium automobile and railway spring steels; machinery, ship and structural forgings; alloy, machinery and commercial forgings; heat treated axles and shafts; steel wheels and tires, carbon shell steel, rifle barrels, small arm parts and low carbon open hearth and Bessemer cold drawn screw stock.

Class 3—High tensile carbon and alloy steels containing 0.60 to .070 per cent manganese. In this class is included gun forgings and castings, marine and heavy machinery forgings and castings, structural ship steels, automobile bar stock, forgings, etc.

Class 4—High carbon low manganese steels, high carbon and other steels involving comparatively small tonnage. This would include file steel, armor plate, armor-piercing shells, carbon and alloy tool steels, carbon spring steel, nickel chrome commercial bar stock, punches and dies, etc.

The tonnage of ingots of these classes was approximately as follows for the year 1916:

Class	Tons	Per cent of production
1	21,350,000	49.89
2	11,990,187	28.06
3	9,008,186	21.07
4	417,307	0.98

Class 1—The steels of class 1 are considered as low tensile, or soft steel, having as a rule an ultimate strength below 70,000 pounds per square inch. The method of manufacture for the same grades varies between manufacturers. Some prefer to make what is known as "dead" steel, which contains on an average 0.60 per cent manganese; others "churned" or "rimmed" steel, analyzing on an average 0.35 per cent manganese. We will assume that the average of all steels in class 1 is 0.50 per cent manganese. The residual manganese in the steel bath in the furnace would be less than 0.10 per cent, so that with 30 per cent loss of manganese added, this steel would require an addition of 0.60 per cent of metallic manganese, or a total of 128,100 tons.

Class 2—In class 2 the manganese varies from 0.40 per cent to 1.40 manganese, the average being about 0.70 per cent. The method of adding manganese to these steels varies considerably, depending upon plant construction and the individual opinions of the operators. At present there are five methods in common use for adding manganese.

(a) Adding cold crushed ferro-manganese in the ladle or furnace.

(b) Melting ferro-manganese in electric or oil furnace, or in special cupolas, and adding molten in the ladle.

(c) Melting spiegel in a cupola and adding direct or diluted into the ladle.

(d) Adding about 5 per cent manganiferous pig iron from mixer or cupola to furnace or ladle.

(e) Recarburizing with 1 to 2 per cent manganese iron in the furnace or ladle and adding the balance of the manganese in alloy form.

In this class of steels probably the greatest proportional conservation of manganese could be accomplished. Assuming a residual manganese of 0.10 per cent before tapping, and a normal manganese loss of 20 per cent, this class would require an addition of

0.75 per cent manganese, or a total of 89,986 tons of manganese.

Class 3—In class 3 a considerable percentage of the product to-day is forgings for guns and ships and castings made from both acid and basic steels. These steels we will consider as high grade products, low in sulphur and phosphorus. It is a common practice to add in the neighborhood of 0.20 to 0.30 per cent manganese to the charge in the form of ferro-manganese or low phosphorus spiegel in order to increase the manganese content of the charge to about 1 per cent. These steels will average 0.65 per cent manganese in the finished product, and will have a normal manganese loss of 20 per cent. With a residual manganese of 0.15 per cent before tapping, the final additions would be 0.63 per cent. With 0.20 per cent manganese charged, the total requirements would be:

In charge	18,016 tons manganese
Final additions	56,751 tons manganese
Total.......................	74,767 tons manganese

Class 4—In class 4 the manganese additions are small; for to use a mill term the heats are "caught coming down" as carburization is started when the desired per cent of carbon is reached, and the manganese as a rule, is within specifications. We will say that this grade requires an addition of 0.10 per cent on an average, or 417 tons of manganese.

The total manganese requirements from 1916 figures are therefore:

Class 1........................	128,100 tons manganese
Class 2........................	89,986 tons manganese
Class 3........................	74,767 tons manganese
Class 4........................	417 tons manganese

equivalent of 366,600 tons of 80 per cent ferro-manganese.

Manganese Supply for Steel Manufacture.

The manganese alloy production and imports of the United States for 1917 was:

Ferro-manganese produced	286,000 tons
Ferro-manganese imported	45,381 tons
Spiegel produced	193,291 tons
Total contained manganese produced and imported	304,000 tons
Manganese ore imported................	629,971 tons
Ferro-manganese from imported ores.:.	300,000 tons
Contained manganese in alloy produced from imported ores..................	240,000 tons

The domestic production of high grade manganese ore for 1917 is estimated by the United States Geological Survey at 122,275 tons, and this is expected to reach 172,900 tons in 1918. Using the 1918 figure this will net us but 70,000 tons of 80 per cent ferro-manganese, or 56,000 tons of contained manganese. The low grade ores are being produced at an estimated rate of 800,000 tons for 1918. This will yield about 340,000 tons of an alloy containing an average of 35 per cent manganese, or 119,000 tons of contained manganese.

The situation is, therefore, briefly this: We require, at our present rate of steel production, present specifications and methods, 293,270 tons of contained manganese per year, and we are producing at the rate of 175,000 tons from our own raw materials.

There is no question that the importation of manganese ores or ferro-alloys is undesirable at the present time. We have the manganese in our country—enough manganese to be independent for some years; we can produce it and can certainly devise means to make it applicable to our steel production in the immediate future. We have been accustomed to the use of 80 per cent ferro-manganese in the manufacture of open hearth and soft Bessemer steels, but we can substitute lower per cent manganese alloys for this work, which can be produced in our own country, particularly if the specifications for steel have their manganese limits reduced.

The majority of the steels in class 1 could be "churned" or "rimmed" steel with 0.20 to 0.40 per cent manganese, and of as good quality, and at the same time eliminate the use of high grade ferro-manganese.

In class 2 recarburizing could be done with 5 to 6 per cent manganiferous iron, or spiegel and iron below .15 phosphorus mixed in the proper portions and added molten.

In class 3 the highest grade ferro-manganese could be used for probably half of the product. With comparatively low carbon and high manganese, the low grade manganese alloys would not be suitable because of the proportion of manganese to carbon. In acid steels of low phosphorus, the use of the lower grade alloys would be prohibitive, due to the impossibility of producing a low phosphorus low manganese alloy.

In class 4 spiegel or alloys containing less than 20 per cent manganese could be used entirely.

By using pig iron containing 2.00/2.50 per cent manganese in open hearth charges, the residual manganese in the steel before tapping will vary between 0.20 to 0.40 per cent, so that in many cases further additions of manganese for deoxidizing purposes are not required, and the final managnese additions are for physical properties only. With basic steel at 0.40 per cent carbon, 10 points of manganese would add 2,500 pounds per square inch to the tensile strength. The same effect could be accomplished with three to four points of carbon. As an example, all the standard specifications for open hearth rails to-day call for manganese limits from .60 to .90. There is no reason why this specification should not be changed, reading manganese .40—.70, with a higher carbon adjustment to give the same physical qualities. It would appear, therefore, that at least an average of 15 points of manganese could be reduced in the specifications for steels in class 2.

Without the use of high manganese pig iron in the charge, assuming our previous conclusions are possible, the requirements of ferro-manganese and spiegel and lower manganese alloys would be as follows:

	Metal Mn. Required	80% Fe. Mn.	60% Fe. Mn.	40% Fe. Mn.	20% Fe. Mn.	6% Fe. Mn.
Class 1...	100,345	......	25,085	40,138	346,200	....
Class 2...	71,990	......	......	......	179,975	598,715
Charge 3.	18,016	35,470	......	......	141,880	300,300
Final	56,751	......	......	......	....	....
Class 4...	417	......	......	......	2,085	....
Total..	247,519	35,470	25,085	40,138	670,140	899,015

By changing or standardizing our method of recarburizing, adopting a standard process for the manufacture of soft steels, and lowering our specified manganese requirements where possible, we can reduce the total tonnage of manganese from 293,270 tons to 247,519 tons, or 15.6 per cent. Further, the requirements of 80 per cent low phosphorus ferro-manganese is reduced to 35,470 tons.

The estimated production of 80 per cent ferro-manganese from domestic ores will net us 70,000 tons for 1918, which is sufficient for the country's needs. The manufacture of 60 per cent ferro-manganese will require high grade ores, so that 25,085 tons of 60 per cent ferro-manganese will lower the possible production of 80 per cent from 70,000 tons to about 51,200 tons. Forty thousand, one hundred and thirty-five tons of 40 per cent ferro-manganese should be made from the lower grade ores. This will require approximately 100,000 tons of ore. This leaves about 700,000 tons which will produce 520,000 tons of alloy averaging 20 per cent manganese. This would leave a shortage of 150,140 tons of spiegel.

In the last 12 years the spiegel production has varied from 83,000 to 348,000 tons per year. What proportion of the ore available for the manufacture of 35 per cent manganese has heretofore been used for spiegel manufacture is impossible to estimate without a detailed canvass of the various producers. The fact remains, however, that there are great quantities of low grade manganiferous iron ores in this country. The use of 1.50 to 2.50 manganese pig iron in the open hearth charge would reduce the quantity of manganese required for additions, approximately 15 per cent for basic open hearth steels, or a further reduction of 10.6 per cent manganese in the total steel produced

There is ample reserve of ores to produce sufficient 5 to 6 per cent manganese recarburizing iron for a considerable period. The annual requirements of this grade would be approximately 900,000 tons, which could probably be increased to produce a further saving of 20 per cent spiegel.

Phosphorus Content of Manganese Alloys.

It has been customary for us to specify a phosphorus content in ferro-manganese of not over .250 per cent. This is probably not so vital as we have always considered it. For example, an addition of 0.60 per cent manganese using 80 per cent ferro-manganese of 0.25 per cent phosphorus, would cause a phosphorus addition to the steel of less than .002 per cent. In most cases this limit of .25 per cent could be appreciably increased without affecting the quality of the product. The addition of 0.50 per cent manganese through the use of spiegel would add to the steel 12 points of carbon, and assuming we could afford to .015 points of phosphorus, the spiegel could contain 0.600 per cent phosphorus, (which is well above the content which spiegel produced from our own ores would contain). For basic steels this would be no hardship; for sheets and tin plate it would be an advantage, but for high grade acid steel the 80 per cent ferro-manganese would necessarily be used on account of the phosphorus.

The phosphorus content of our domestic ores is roughly estimated as follows. The estimated production for 1918 is from the United States Geological Survey.

High grade manganese ores—40 per cent and above.

State	1918 productions	Probable phosphorus content
Alabama	200	0.200
Arizona	22,000	0.050
Arkansas	10,000	0.200
California	12,000	0.100
Colorado	500	0.200
Georgia	5,000	0.100
Montana	81,600	0.050
Nevada	2,500	0.100
New Mexico	1,500	0.100
North Carolina	100	0.150
South Carolina	2,000	0.150
Tennessee	5,000	0.150
Texas	2,000	0.050
Utah	4,000	0.150
Virginia	20,000	0.200
Washington	1,000	0.100
Wyoming	500	0.100
Total	169,900	

Low grade ores for manufacture of 35 per cent ferro-manganese:

State	1918 productions	Probable phosphorus content
Appalachian region	40,000	0.200
Arizona	25,000	0.100
Colorado	100,000	0.200
Lake Superior	150,000	0.200
Lake Superior	150,000	0.090
Montana	25,000	0.080
New Mexico	36,000	0.100
Zinc residuum	175,000	0.040
Miscellaneous	15,000	0.200
Total	716,000	

A serious difficulty which becomes apparent from the above tabulation is the selection of furnaces for the manufacture of the various alloys, the economic transportation of raw materials and the distribution of the product to the best advantage. How this can be done will require thought and coöperation on the part of all consumers of manganese.

Conclusion.

As a metallurgical proposition we have tried to show how the manganese situation of to-day can be met in the various steel making departments in our own plants and, if we assume that we are representative of the industry by applying the same methods to the country as a whole, we feel that the situation can be met.

The steps as outlined are briefly:

1. United effort and coöperation of all steel producers on a predetermined set of plans.
2. Coöperation of the steel consumer in revising downward the specified percentage of manganese in finished steel and upward allowable limits of phosphorus.
3. The use of manganiferous iron in open hearth charges to increase the residual manganese in the open hearth process.
4. The production of a majority of soft steels by the "churning" or "rimming" method.
5. The use of approximately 6 per cent manganese iron with phosphorus below .150 per cent for recarburizing.
6. The use of 20 per cent spiegeleisen, 60 and 40 per cent ferro-manganese for recarburizing.
7. The use of 80 per cent ferro-manganese only in high grade low phosphorus acid steels, high speed and carbon tool steels made by the crucible process and manganese steel of 11 to 14 per cent.
8. Each individual plant will have its own problems; some will not be properly equipped, some will be making specialties of which we have no record. The problems will be many and difficult, but they can be worked out, if the united determination of the manufacturers is—that it will be worked out.

With our present methods of recarburizing, if imports were suddenly cut off, we would find our production of steel greatly impaired. Our country is actually short less than 160,000 tons of 20 per cent spiegel, or 11 per cent of our manganese requirements, if we will use to best advantage the ores that we are producing at our present rate. But with our present methods we are short approximately 40 per cent. The ores are available for spiegel production, but they must be mined and converted.

It cannot continue to be a question of costs, nor can the usual routine of specifying and buying ferro-manganese remain. This situation demands the guidance of a strong, able, impartial committee of the Iron and Steel Institute which knows, and can tell or show how our materials are to be used.

With such a body of men and the hearty coöperation of every steel plant in the country, we can make our greatest manufacturing industry as independent as it is great.

Phosphorous in Soft Open Hearth Steel

Results of Investigation of the Effects of Phosphorus in Soft Acid and Open Hearth Steels Show That Hardness Increases With Increased Phosphorus, but Steels Are Not Made Brittle or Cold Short.

By J. S. UNGER.

PART I.

J. S. UNGER,
Manager, Central Research Bureau, Carnegie Steel Company, Pittsburgh.

> *"The purpose of this investigation was to compare soft acid and basic open hearth steels of varying phosphorus content, and of as nearly the same composition in other respects as it was possible to secure in a practical way, to determine what differences would be obtained by means of different mechanical tests, particularly by fabricating finished articles."*

The purpose of this investigation was to compare soft acid and basic open hearth steels of varying phosphorus content, and of as nearly the same composition in other respects as it was possible to secure in a practical way, to determine what differences would be obtained by means of different mechanical tests, particularly by fabricating finished articles requiring severe cold working for their production.

General.

Every metallurgist knows that phosphorus adds hardness to steel in the same manner that carbon or any true hardening element does. Many persons believe that, in addition, it produces brittleness or what is called cold shortness.

Soft or low carbon steels are made up in the cold state into many articles requiring severe stamping, pressing, drawing, bending or upsetting operations. Articles of medium or high carbon steel requiring such operations are usually worked hot, giving very little opportunity to observe their properties until after they have become cold.

Soft steels for use in articles requiring severe cold working in their production are rarely tested by means of physical tests, the fitness or unfitness of the steel being determined by the ability to fabricate the steel and meet the requirements of ordinary service.

For this reason more attention was given to the fabrication of finished articles in this investigation, although physical tests of various kinds were made.

Large numbers of the several articles were made

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up cold in a practical way, the aim being to carry out the experiment in accordance with current conditions, being careful not to change the shop conditions or methods of operating at any particular plant. By making a considerable number of each article, a fair average result was obtained, which is considered to be truly representative of regular shop practice.

The steels were not given any special heat treatment, excepting such as is regularly given to ordinary soft steels, for instance the annealing of sheets or the pickling and annealing of wire. The effects of heat treatment was not studied, as soft steels are rarely heat treated. A few tensile and other tests were made on some heat-treated bars for information only.

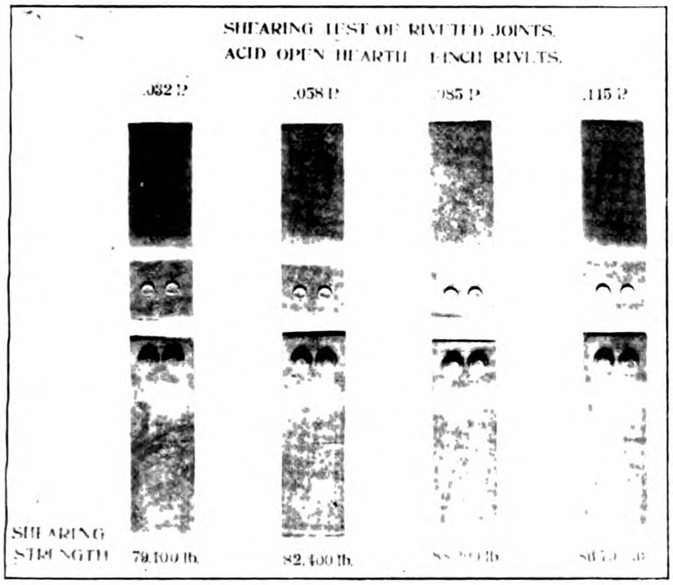
SHEARING TEST OF RIVETED JOINTS.
ACID OPEN HEARTH 1-INCH RIVETS.
.032 P
.058 P
.085 P
.115 P
SHEARING STRENGTH
79,100 lb.
82,400 lb.

Fig. 1.
Figs. 1 and 2 show results of testing rivets.

Composition.

Twelve ingots from the same heat of acid steel and 15 from the same heat of basic open hearth steel, or 84 tons in all, were used in this experiment. The normal composition of each steel is given in Table I.

After the first three basic ingots had been poured, sufficient 17 per cent powdered ferro-phosphorus was added during the pouring of the next three ingots to increase the phosphorus to .030 per cent. To the following three ingots the addition was increased to show a phosphorus content of .055 per cent, the next three to .085 per cent and the next three to .110 per cent phosphorus. The same method was adopted in the ingot additions to the acid steel, excepting that only three sets of three ingots each, had additions of ferro-phosphorus made to them, as the original phosphorus in the steel was higher to begin with.

The ferro-phosphorus additions to the last set of ingots of each steel raised the phosphorus considerably above that regularly found in either acid or basic open hearth steel, but these additions were made to secure steels containing as much phosphorus as is ordinarily found in Bessemer steel. Any higher phosphorus content than that found in Bessemer steel was of no practical value, consequently a study of steels containing higher percentages of phosphorus was not considered.

The method described furnished steels practically alike in every particular, except in the amount of phosphorus they contained; therefore any differences found in the tests or finished products could be attributed to the phosphorus content.

All the phosphorus in the ferro-phosphorus was absorbed by the molten steel without appreciable loss. The amount of phosphorus found in the ingots and the various steel articles checked the phosphorus additions very closely.

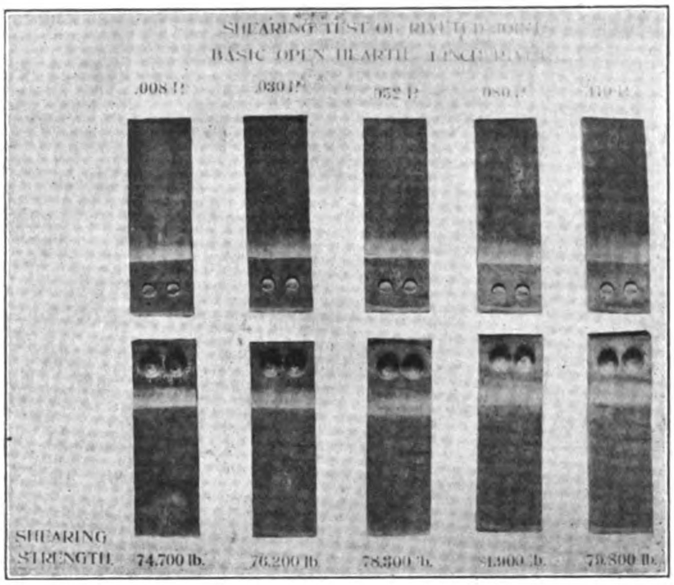

Fig. 2.

Table I—Composition of the Steel.

Kind of steel	C.	Mn.	Phos.	S.	Si.	Cu.
Acid open hearth (ladle analysis)	.12	.36	.032	.036	.020	.014
3 ingots	...	...	.058	....	....	....
3 ingots	...	...	.085	....	....	....
3 ingots	...	...	.115	....	....	....
Basic open hearth (ladle analysis)	.12	.36	.008	.037	.022	.012
3 ingots	...	...	.030	....	....	....
3 ingots	...	...	.052	....	....	....
3 ingots	...	...	.080	....	....	....
3 ingots	...	...	.110	....	....	....

Rolling.

The ingots were stripped and charged hot into the soaking pits, heated and rolled in the regular way into billets, slabs and sheet bar. A discard of about 25 per cent was made from the top of each ingot to remove pipe, sponginess or unsoundness. None of this material was chipped after rolling, and no difference was observed between the different ingots in the rolling mill. These semi-finished products were then shipped to the various mills to be rolled into sheets, wire rods and rounds, from which the finished articles were made.

Physical Tests.

Longitudinal and transverse tensile, cold bending and drifting tests were made on the sheet bar, which was 0.467-inch thick. Tensile, vibratory and impact tests were made on the untreated and treated 1-inch rounds, and in addition, shearing tests were made on the same material, untreated. Longitudinal and transverse specimens from sheets .096-inch thick were tested by alternate bending, and specimens from sheets .048-inch thick were tested for their drawing qualities by the Erichsen test. Tensile tests were made on both the wire rod and the wire.

The results of these tests are shown in Tables II to IX.

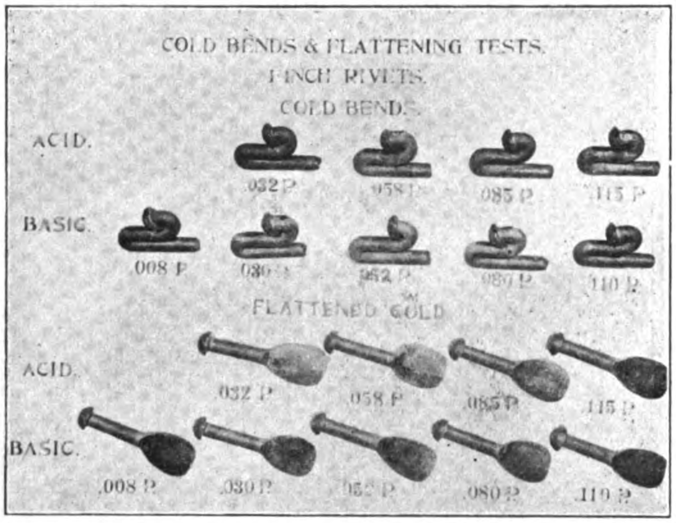

Fig. 3—Rivets after testing.

TENSILE TESTS ON SHEET BAR .467'' THICK.

Table II—Longitudinal.

Kind of steel	Phos. content	Elastic limit, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Elongation in 8", %	Reduction of area %
Acid O. H.....	.032	30,750	54,280	29.3	58.7
Acid O. H.....	.058	31,215	57,290	32.0	58.7
Acid O. H.....	.085	33,120	59,200	30.6	57.1
Acid O. H.....	.115	35,665	62,070	29.4	47.0
Basic O. H....	.008	29,130	50,780	34.3	61.0
Basic O. H....	.030	30,405	51,940	32.4	63.2
Basic O. H....	.052	30,675	54,350	32.4	62.6
Basic O. H....	.080	30,540	55,820	31.2	56.8
Basic O. H....	.110	32,550	58,635	31.2	55.9

Table III—Transverse.

Kind of steel	Phos. content	Elastic limit, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Elongation calculated to 8"	Reduction of area, %	Actual elongation in 2"
Acid O. H..	.032	32,320	55,840	28.0	48.1	41.0
Acid O. H..	.058	32,550	59,410	24.0	43.9	35.0
Acid O. H..	.085	31,840	59,530	29.0	41.1	43.0
Acid O. H..	.115	35,770	63,700	24.0	46.4	35.0
Basic O. H.	.008	30,900	52,400	29.0	48.5	43.0
Basic O. H.	.030	31,160	53,440	27.0	49.9	40.0
Basic O. H.	.052	31,010	55,840	28.0	51.2	41.0
Basic O. H.	.080	31,840	57,740	26.0	44.9	38.0
Basic O. H.	.110	33,060	60,970	27.0	41.0	40.0

These tests were made in duplicate and the averages are shown in the tables. With the same phosphorus content, the acid steel shows approximately 3,000 pounds higher ultimate than the basic. On account of the width of the sheet bar, the transverse tests were pulled in 2-inch sections and calculated to 8-inch for comparison.

Longitudinal and transverse bends were made on the same material. All longitudinal bends closed up flat without showing any cracks on the outer surface. The transverse bends were closed until slight cracks could be seen, the bending then being stopped.

Drift Tests.

These tests were made on 18-inch pieces from the sheet bar, having three holes 15/16-inch diameter along the center of specimen, sufficient distance betweel holes and from the ends of piece to avoid disturbing the surrounding metal. The upper hole was punched away from the surface, the center hole was drilled and the lower hole was punched towards the surface. A drift ⅞ inch at the small end and 2¾ inches at the large end and 13 inches long was forced into each hole until cracks appeared at the edge of the hole on the under surface. The load required and the diameter of the hole after drifting are given in Table IV.

Table IV—Drift Tests.

Kind of steel	Phos. content	Diam. hole punched away from surface	Load req.	Diam. drilled hole	Load req.	Diam. hole punched towards surface	Load reg.
Acid O. H..	.032	1.26"	28,000	1.65"	35,200	1.46"	27,600
Acid O. H..	.058	1.23"	32,700	1.58"	31,000	1.39"	30,100
Acid O. H..	.085	1.26"	32,400	1.44"	30,800	1.35"	30,700
Acid O. H..	.115	1.22"	33,200	1.40"	34,100	1.42"	32,000
Basic O. H.	.008	1.30"	28,400	1.83"	32,200	1.45"	25,100
Basic O. H.	.030	1.26"	27,400	2.00"	35,900	1.58"	27,500
Basic O. H.	.052	1.28"	28,100	1.65"	31,800	1.50"	27,500
Basic O. H.	.080	1.32"	28,600	1.70"	33,500	1.47"	28,000
Basic O. H.	.110	1.30"	28,600	1.64"	34,300	1.35"	29,100

TENSILE TESTS ON 1" ROLLED ROUNDS.

Table V—Untreated.

Kind of steel	Phos. content	Elastic limit, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Elongation in 8 in., %	Reduction of area, %
Acid O. H..	.032	39,910	55,450	26.8	66.5
Acid O. H..	.058	40,130	56,880	25.0	64.2
Acid O. H..	.085	41,540	59,640	26.2	64.0
Acid O. H..	.115	42,900	60,640	26.0	65.9
Basic O. H.	.008	34,410	49,350	28.7	71.6
Basic O. H.	.030	37,350	51,380	29.0	70.9
Basic O. H.	.052	38,060	52,240	28.3	70.3
Basic O. H.	.080	40,530	55,840	27.5	70.3
Basic O. H.	.110	40,180	57,000	23.7	60.2

Table VI—Treated.*

Kind of steel	Phos. content	Elastic limit, lbs. per sq. in.	Ultimate strength, lbs. per sq. in.	Elongation in 8 in., %	Reduction area, %
Acid O. H..	.032	47,490	64,280	21.2	71.6
Acid O. H..	.058	49,380	65,520	21.8	67.5
Acid O. H..	.085	51,800	67,720	21.7	68.7
Acid O. H..	.115	51,840	68,700	19.3	67.5
Basic O. H.	.008	42,780	54,100	28.1	80.6
Basic O. H.	.030	45,580	57,260	28.5	78.4
Basic O. H.	.052	46,380	59,340	26.2	74.5
Basic O. H.	.080	46,500	60,020	27.8	75.1
Basic O. H.	.110	46,840	61,860	25.0	65.0

*The treatment consisted in quenching in water at 800 deg. C. and drawing back at 600 deg. C.

Vibratory and Impact Tests.

The vibratory tests were made on specimens ⅜ inch in diameter by 6 inches long. The specimens were gripped 4 inches from one end and vibrated ⅜ inch in each direction at 650 vibrations per minute until failure occurred. The specimens were long enough to make a test at each end.

In the impact tests, a standard S. A. E. specimen, 10 mm square, notched 2 mm deep and 1 mm wide, was tested with a 200 foot-pound pendulum machine, without being able to break the specimen, as they were so tough they would bend over and wedge under the tup. Repeated trials by cutting the notch 5 mm deep did not improve matters. The notch was finally cut 6½ mm deep and turned away from the tup, when a clean break was obtained.

The writer's previous experience with both vibratory and impact tests has led him to place little confidence in either test, and the present tests have not proven an exception.

These tests, particularly the impact tests, were made to try to show that the higher phosphorus steels were brittle under a dynamic or shock test. Nothing seems to be indicated by the conflicting results and nothing is claimed for them, excepting that they have not shown any greater brittleness on the high phosphorus than on the lower phosphorus steels. They are inserted as a matter of interest only. The vibratory tests are the average of four tests, the impact the average of two tests.

The results of the vibratory and impact tests are shown in Table VII.

Table VII—Results of Vibratory and Impact Tests.

Kind of steel	Phos. content	No. of vibrations Untreated	No. of vibrations Treated	Impact foot pounds Untreated	Impact foot pounds Treated
Acid O. H.	.032	1,236	1,355	34.2	48.6
Acid O. H.	.058	1,415	1,236	41.4	50.4
Acid O. H.	.085	1,213	1,044	34.2	41.4
Acid O. H.	.115	1,041	1,244	46.8	37.8
Basic O. H.	.008	1,491	1,255	32.4	41.4
Basic O. H.	.030	1,477	1,314	39.6	41.4
Basic O. H.	.052	1,422	1,302	48.6	55.8
Basic O. H.	.080	1,451	1,369	46.8	50.4
Basic O. H.	.110	1,305	1,331	48.6	54.0

The treated steel was quenched at 880 deg. C. in water and drawn back at 600 deg. C.

Shearing Tests and Riveted Joint Tests.

The shear tests were made on specimens ¾ inch in diameter, subjected to double shear in a shearing block, using a shearing blade 1 inch thick. Riveted joints were prepared by riveting up a joint of two bars 5 inches wide, 1¼ inch thick with two 1-inch hot-driven rivets, spaced 2 inches from center of rivets and 1½ inches from end of bars. The riveted joints after breaking are shown in Figs. 1 and 2.

The results of these tests are given in Table VIII.

Tests on the Rivets.

Several rivets 12 inches long from each grade of steel were cold flattened to ¼ inch thick, as shown in Fig. 3, no cracks developing on the flattened edges. Additional rivets were gripped under the head in a strong clamp and bent into a rough shape like the letter "S," afterwards being closed up tight under the steam hammer, to try to snap the head off or break the rivet by bending under cold impact. No cracks developed on bending. Fig. 3 shows the rivets after testing.

Table VIII—Results of Shearing Tests and Riveted Joint Tests.

Kind of steel	Phos. content	Load to double shear ¾" diam. rounds	Strength of hot riveted joint, two 1" diam. rivets
Acid O. H...	.032	36,985 lbs.	79,100 lbs.
Acid O. H...	.058	38,830 lbs.	82,400 lbs.
Acid O. H...	.085	40,165 lbs.	88,200 lbs.
Acid O. H...	.115	40,080 lbs.	86,700 lbs.
Basic O. H...	.008	34,845 lbs.	74,700 lbs.
Basic O. H...	.030	36,180 lbs.	76,200 lbs.
Basic O. H...	.052	36,475 lbs.	78,300 lbs.
Basic O. H...	.080	36,340 lbs.	81,900 lbs.
Basic O. H...	.110	36,220 lbs.	79,800 lbs.

Bending and Erichsen Tests on Sheets.

Longitudinal and transverse tests 1 inch wide were cut from sheets .096 inch thick and given a bending test by gripping vertically in a vise and attaching a clamp to the part projecting above the vise jaws, fastening the clamp the thickness of sheet above the jaws; then bending back and forth through an angle of 90 deg. from both sides of the vertical until broken. Each motion through 90 deg. is counted as one bend.

Duplicate specimens were tested as rolled and after normalizing at 900 deg. C. for five minutes.

Drawing tests were made in duplicate on the Erichsen machine on sheets .048 inch thick. The results are shown in Table IX.

Table IX—Results of Bending and Drawing Tests.

Kind of steel	Phos. content	Bending test—Sheets .096" thick. No bends. As rolled.		Normalized at 900 deg. C.		Erichsen test. Sheets .048" thick. Depth of cup
		Long.	Trans.	Long.	Trans.	
Acid O. H..	.032	3	3	4	4	9.22 mm
Acid O. H..	.058	4	3	5	4	9.08 mm
Acid O. H..	.085	3	3	4	4	9.04 mm
Acid O. H..	.115	3	2	4	3	8.71 mm
Basic O. H..	.008	4	4	4	4	9.77 mm
Basic O. H..	.030	4	3	4	4	9.65 mm
Basic O. H..	.052	3	3	4	4	9.35 mm
Basic O. H..	.080	3	3	4	3	9.13 mm
Basic O. H..	.110	4	3	5	4	9.23 mm

Cold Drawn Shafting.

Duplicate rolled rounds 30 feet long and 1.016 inch diameter were pickled at one time in the same acid solution and then drawn into rounds .033 inch in diameter. The noticeable thing was the greater action of the pickling acid as the phosphorus increased. This is shown in the gradually decreasing diameters and the condition of the surface of the bars before drawing. This was pronounced enough to enable one to tell the phosphorus content by the diameter of the bar after pickling. The results will be given in the next issue of THE BLAST FURNACE AND STEEL PLANT.

The By-Product Coke Oven Industry

The By-product Coke Oven Industry Is Vitally Essential in the Prosecution of the War, Not Only from an Economic Standpoint, but Also in the Furnishing of Raw Materials.

By WILLIAM H. BLAUVELT,
Consulting Engineer, Semet-Solvay Company.

W. H. BLAUVELT,
Consulting Engineer, Semet-Solvay Co., Syracuse, N. Y.

"This industry has done much more for America than the conservation of our fuel resources in furnishing a supply of raw materials for our high explosive shells. It has taken an important part in the development on a sound basis of a wide line of chemical industries, in which our country was so far behind others."

For many years European economists have felt that it was a reproach to the United States that it should cling so long to the bee-hive oven for the manufacture of coke and deliberately throw away millions of dollars' worth annually of the many valuable by-products obtainable from the distillation of coal. Most fortunately for us in this great crisis through which we are now passing, this reproach is being rapidly removed. Forty per cent of the coke made in 1917, or 22,600,000 tons, was by-product coke, and some time this year, as the new plants come into run, the production of by-product coke will pass the bee-hive output. Ovens with a capacity of 13,500,000 tons of coke are in process of construction, and half as much more is contemplated. What did this great and rapidly growing industry mean to us as we entered the war a year ago and began our preparations for taking our place as active combatants in this greatest of all struggles?

From the side of fuel conservation, which last winter's experience showed us to be of the most vital importance, the by-product ovens now in run have a capacity for producing 5,000,000 more tons of coke per annum than if the same coal had been coked in bee-hive ovens. Moreover, they have made possible the utilization for coking purposes of many deposits of coal that otherwise would not have been available.

Assuming all the plants were in full run, they would produce 315,000,000 gallons of tar, which may be used for fuel, having the same efficiency as fuel oil, to say nothing of its other important uses in the arts. Assuming an average production of 4,000 feet of surplus gas per ton of coal, including ovens of the older and newer types, the average annual production is 168,000,000,000 feet of gas, which would melt 12,000,000 tons of steel in the open hearth furnace.

But it is in furnishing raw materials for high explosives that the by-product oven industry is most vitally essential to our prosecution of the war. Entirely aside from the economic importance of the conservation of our Nation's resources, which is so vital at this time, if this industry had not been developed, we should have had to depend entirely upon the allies for almost every pound of high explosives, without a plentiful supply of which, this highly scientific warfare could not have been carried on by us for a single day, and, as we know, the allies have had to utilize every resource to obtain sufficient raw materials for producing their own explosives. Practically all of the high explosive shells used at the battle front are loaded with picric acid, T. N. T. and ammonia powders. Picric acid is tri-nitro-phenol, which is produced by nitrating phenol or carbolic acid. Carbolic acid has been produced for many years from the distillation of coal tar, but under present conditions in this country very much the larger production of carbolic acid is obtained by the synthetic process by the sulphonation and nitration of benzol. T. N. T., or tri-nitro-toluol, is produced from the direct nitration of toluol, and the ammonia powders have, of course, ammonia as their base. With the exception of a relatively small production from gas works, all our supply of these products is obtained from the distillation of coal in the by-product oven. The ovens now in run have a capacity for carbonizing 42,000,000 tons of coal per year, and those building or planned will add 70 per cent of this amount. The present tonnage means an output of approximately 63,000,000 gallons of chemically pure benzol, 14,000,000 gallons of toluol and 100,000 tons of ammonia. I need only call your attention to these figures to demonstrate to you the importance of the by-product industry to our war requirements. It is not pleasing to contemplate what would have been our position if the large development of the by-product oven had been delayed only a few years.

This industry has done much more for American than the conservation of our fuel resources and furnishing a supply of raw materials for our high explosive shells. It has taken an important part in the development on a sound basis of a wide line of chemical industries, in which our country was so far behind others

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Paper read before May meeting of the American Iron and Steel Institute.

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until quite recent years. American manufacturers have had the money and will, and American chemists have had the brains and the knowledge, but until the products of coal distillation were available as raw material, we made little progress in some of the great branches of chemical manufacturing, which had been so highly developed in European countries. The great color and dye industry is a notable illustration of this fact. While this industry itself is represented by relatively small values dependent upon it. We learn from government reports that there are over 14,000 establishments in our country which are absolutely dependent upon dyes and colors. These establishments employ over $3,000,000,000 capital and it is estimated that over 2,000,000 working men and women are occupied in manufacturing plants which are directly dependent upon the use of artificial dyes and colors, and nearly all of these depend in whole or in part on the products of the distillation of coal for their raw materials. Naturally the color makers turn first to the colors which are consumed in the largest quantities, such as blacks and blues, but the list is being rapidly exended to cover the full line of dyes and colors used by the American trade. Printing inks, both black and colored, depend on the prussiates for their raw material, but it is doubtful whether it is realized in many of the thousands of printing offices in the country that the by-product oven is the basis of their supplies of ink.

From the point of view of the chemical industries, many of the products of the distillation of coal are what are termed keystone products. That is, while they are relatively unimportant in themselves, they are essential to other greater industries, and still others owe their development to the needs created by these keystone industries. For example, aniline, which is made from benzol, and which is the base of a long list of colors, is also the raw material for indigo. In the production of indigo it is necessary to have available a supply of the strongest sulphuric acid, which is entirely beyond the possibility of the old and well-known chamber process. The contact process for producing these strong sulphuric acids was developed to meet this need, utilizing oxygen obtained from the air for the oxidation of the sulphur gases. With this process was developed the fixation of atmospheric nitrogen and the oxidation of ammonia for the production of nitric acid, thereby obtaining independence of the Chilean supplies of sodium nitrate. All of these processes have demanded more and more from the manufacturing chemists, and we have learned the way to be entirely independent of outside sources of raw material in so many lines of manufacturing which are essential to the best national life. Manufacturing chemistry is peculiar in requiring ripe experience in detail by those in direct charge of operations, as well as scientific knowledge of the processes used by those in general control, and the above brief reference will suggest to you the great chain of industries vital to the independent commercial success of our nation, which have been and are being built up in this country now that the supply of "keystone" products has been made available by the by-product oven. After so many years of neglect, the progress we have made in the development of these closely interwoven industries is both remarkable and gratifying.

I have not time to go into the sanitary and medical supplies needed in the medical departments of our armed forces, but salicylate of soda and magnesia, asperin and salvarsan are illustrations of what our medical forces owe to coal distillation products. Perfumes may seem rather aside from preparations for war, but they are practically essential in the manufacture of soaps, pastes, ointments and salves as well as for less important uses, and the base of very many of these perfumes is chlorinated toluol and benzaldehyde.

While very much of our attention is necessarily occupied in the actual conduct of the war and the production of the necessary supplies in a variety which we are only beginning to realize, we are also giving much thought to what is to come after the war. I have endeavored to suggest briefly the many lines of important industries that have grown directly or indirectly from the "keystone" products of the distillation of coal, and others will occur to you. It is most satisfactory to note the courage and energy with which American manufacturers have entered these fields, and the sound commercial basis upon which many of these industries have been established. When the military requirements are over and these manufacturers have been adjusted on the basis of peace requirements, let us hope that our manufacturers, assisted by well considered government aid, may be able to reach an even broader development of these industries than we have discussed and produce all of these hitherto somewhat unfamiliar products necessary for our national life. We have always excelled in mechanical products, although we have often permitted other nations to benefit more largely than we from our inventions, and this great emergency has shown that we are equally capable in chemical manufacturing, once we are assured of the raw materials and are aroused to the importance of these lines of industry.

In a paper read by the author before the A. I. M. E. he adds, that "since the by-product oven was brought to this country from Europe, in 1892, it has been radically improved, and from the point of view of American metallurgical practice it is safe to say that the American ovens are superior to those of Europe. The points of superiority are mainly those of larger units and larger output per unit, and the greater extent to which lavor saving machinery has been introduced. The increased output is largely due to the use of silica refractory material, which permits higher heats and shorter coking time than are employed in Europe. The modern American oven will carbonize commercially more than 20 tons of coal per day, and contrary to the European idea that slower operation is necessary to conserve the plant, this rate of operation can be maintained for an indefinite time."

The Elements of Roll Pass Design

Principles to Be Observed in the Rolling of Channels—Compression of Web and Flanges Which Should Be Kept at Approximately Same Thickness—Avoiding Grinding Action and Cracking.

By W. TRINKS.

Angles are rolled by passing a rectangular bar through angle-shaped rolls, which is similar in its action to forcing angle-shaped dies against a rectangular block. This fact may lead the beginner to suppose that a channel may be rolled by running a blunt-nose roll more and more deeply into a rectangular bloom, as indicated in Fig. 1. Since this series of articles is written for beginners with a view to bringing out the underlying principles, the reasons for failure of the method shown in Fig. 1 will be discussed.

First note that the material in the flanges A is not compressed at all, except indirectly by the slight slant of face B. On the other hand, the compression of web C is very great. The result is that web C, under the influence of the direct compression must become very much longer, against the resisting influence of the flanges A which try to maintain their original length. This, in turn, means that the bar has a tendency to curl up, because in a ring, the inner fibers are shorter than the outer fibers. If the guides on the delivery side are set so that the curling is prevented, then the flanges A are pulled along by the web C. But since the final thickness of the web is one-tenth of that of the original rectangle, or even less, the flanges would be stretched to 10 (or more) times their original length by tension only. The effect is two-fold. First, the flanges shrink by lateral contraction; they are "pulled down" as the mill man says. That is to say, their height decreases, as indicated at point D, Fig. 1. The second effect is tearing of the flanges. Even with lateral contraction possible, the steel tears with so great an elongation, particularly at the low temperatures which the flanges would reach toward the finish. It may be useful to remark in this connection that at average rolling temperatures (2,000 to 2,200 deg. F.) ordinary steel will stand an elongation (by tension) of 2 to 2¼ if lateral contraction is prevented, and of 3¼ to 3½, if lateral contraction is possible to some extent, without tearing.

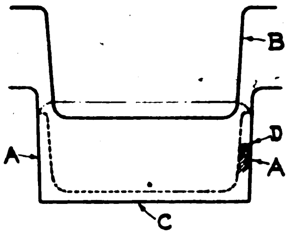

Fig. 1—Wrong way of rolling channels.

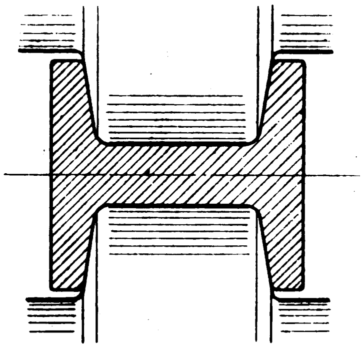

Fig. 2—Puppe's method of rolling beam blanks.

The correctness of this latter contention was proved by Dr. Puppe's method of rolling beam blanks for wide-flanged I-beams. The blank and the method of rolling are shown in Fig. 2 (drawn from memory). The unit elongation does not exceed four and the steel is quite hot while the web is being compressed. No cracks were visible in the blank, although practical mill men had predicted dire failure. In American practice, very few mill men would be willing to go as far as this, because an occasional run of poor steel would certainly give trouble with this method of rolling.

No matter what the method of rolling may be, the finishing pass of any channel must look somewhat like Fig. 3. It will be noticed that, while the two rolls have the same linear velocity at the pitch line, their velocities are different as we go away from that line. The result is a grinding action between the channel and the rolls, which action wears the rolls. Wear is proportional to the product of pressure and rubbing speed; and since the rubbing speed is practically given (for a given roll diameter and a given delivery speed), it behooves us to make the pressure low. For that reason the reduction in the finishing pass is usually made very small, varying from 5 to 12 per cent. In addition, several finishing passes (from two to three) are provided, so as to wear them out one after another. These remarks hold good equally well for I-beams and for rails.

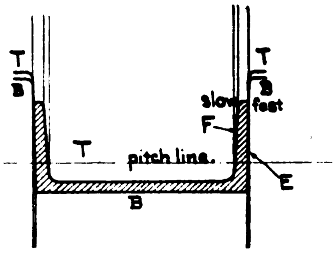

Fig. 3—Finishing pass of channel.

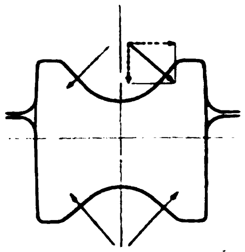

Fig. 7—Diagram illustrating force action in the rolling of beam blanks.

The second important fact, (following from Fig. 3, is that the bounding lines of the flange are not at right angles to the web. In order to free the beam from the roll, and in order to make it possible for the roll-turner to dress the rolls*) the face E makes an angle of ½ to 1½ degrees with a plane at right angles to the roll axis. In the actual use of channels, thsi angle is inconvenient. For that reason, some roll designers bring it down to ½ degree, while others figure on setting the guides on the delivery side so that they squeeze the flange together into right-angle position. At that time, the steel is fairly cold, and it rubs along the guides with the whole delivery speed. For that reason the guide wears, and must be adjusted frequently. The same condition exists with I-beams and with rails, only we do not care in rails whether the flange is at right angles to the web or not.

On the inside of the flange (face F, Fig. 3) an inclination is less harmful in the use of channels. Consequently, roll designers allow more of a slant, the amount of which can be taken from any handbook of structural shapes. By giving the face F some slant, we are in position to give a slight compression to the flanges even in the finishing pass and to properly free the steel from the rolls.

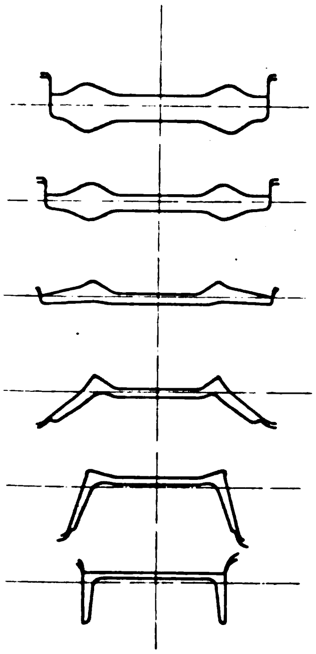

Fig. 4—Sample passes "bending-up" method of rolling channels.

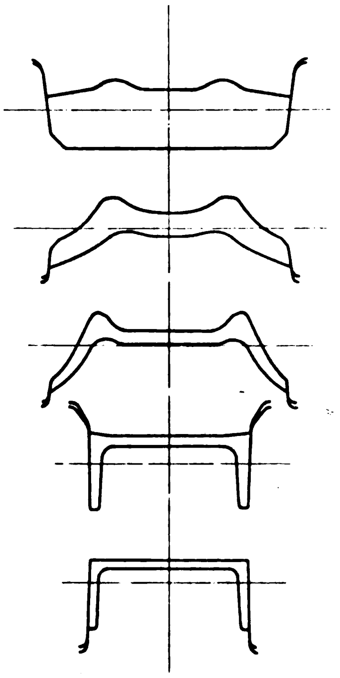

Fig. 6—Sample passes combination method of rolling channels.

From the preceding it is evident that the following principles or rules must be observed in the rolling of channels (and also in the rolling of I-beams):

1—As nearly as possible compress the web and flanges equal fractions (of their entering cross-sectional area) in each pass. This does not mean that the reduction of one pass should equal the reduction of another pass, but it means that, in any given pass, flanges and web should be reduced the same percentage.

2—Keep flanges and web at approximately the same thickness so that they may cool equally. A beam which is delivered to the cooling bed with great temperature differences between web and flanges, either distorts or is full of internal stresses when cold.

3—Avoid too great a grinding action due to different roll velocities at different radii. This statement refers particularly to the pitch diameter of the mill on which a given size channel is rolled. As far as strength is concerned, a small-diameter, but short roll, will be equal to a large-diameter, but long roll. But the latter roll is preferable, because a given depth of pass produces less difference in linear velocity.

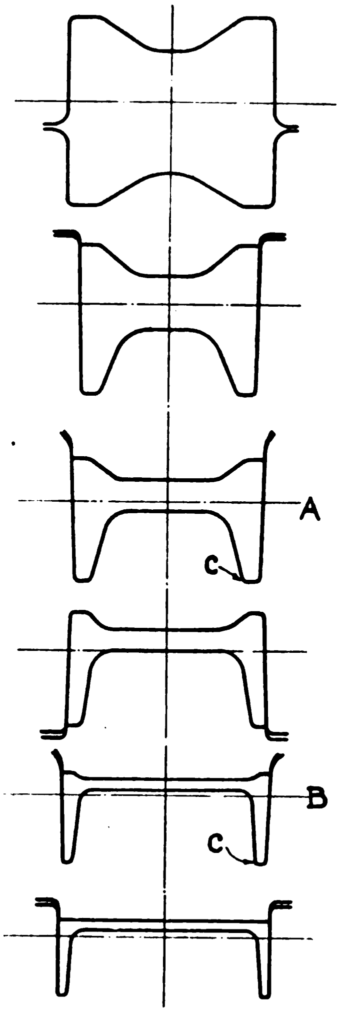

Fig. 5—Sample passes "counter-flange method of rolling channels.

4—Avoid cracking or fraying of the edges. To that end, not only compress the flanges as much as the web, but arrange the rolling process so that work is put right on the outer edge of the flange. Edging passes which are still possible in the early stages of the rolling of sheet bars and of angles (see THE BLAST FURNACE AND STEEL PLANT, March and April, 1918) are clearly out of the question with channels, except in the rolling of beam blanks for channels.

In the process of transforming a rectangular shape into a channel shape, several ways are open, each of which has its advantages and its disadvantages with regard to the four principles or rules which have just been enumerated. In other words, it is possible to change from a rectangle to a channel by passing successively through various intermediate shapes, the latter being very dissimilar in the different methods. Illustrations No. 4, 5 and 6 show three different methods. In each case only a few of the passes are shown for the sake of simplicity, others having been omitted.

The method illustrated by Fig. 4 may be termed the bending-up method. It corresponds to the butterfly method of rolling angles. Rolling by this method involves very little grinding action, because all of the heavy reduction work is done before the bending begins. On the other hand, the channels while still in the shape of flats take up a lot of space in the direction of the roll axis. The lumps in the intermediate passes serve two purposes:

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*If the sides of the pass are inclined, the pass may be restored to its original shape and dimensions, after it has become worn, by cutting deeper into the roll (slightly reducing the roll diameter); but if the sides are perpendicular to the roll axis, the pass can be restored to its original dimensions only by reducing the roll radius by the whole depth of the pass, which, as a rule, is out of the question on account of lack of strength of the roll.

First, they are needed to furnish the material for the outer corner in the bending process. But they are made much larger than is necessary for that purpose. The excess serves the purpose of protecting the flanges from tearing. From previous installments it is known that wide sheet bars, skelp and plate do not spread on account of the ribbon-like shape of the projected contact area. In order to insure easy entering of the bar right straight through, it is desirable to have each following pass a little wider than the preceding one. And to insure not only filling under these conditions, but also some side pressure, it is necessary to compress more near the edges than directly in the center. And that condition is attained by the bumps or lumps, as shown.

The method illustrated by Fig. 5 may be termed the counterflange method. The beam blank is started just like the blank for an I-beam; but the counterflange on one side is removed step by step. This method requires less length of roll per pass, but it produces more grinding action on the rolls than the method of Fig. 4. The great inclination of the interior faces in the early passes (Fig. 7) has a very good effect. The pressure of the rolls being inclined, as indicated by the arrows, causes the material in the web-to-be to not all go into length, but to flow voluntarily into the side parts which are to form the flanges. Consequently, there exists no tearing action on the flanges in these early passes.† In the later passes, the tearing action is avoided by pressing the counterflange into the real flange. If too much of the counterflange is removed in one pass, a fin is produced. It is, therefore, evident that by careful design and adjustment of rolls the flange can be protected, and that work can be done upon it. This is particularly noticeable from the study of the passes A and B, Fig. 5. In both passes the flange is pushed down into the deal hole so that its edges C can be subjected to strong pressure.

The method illustrated in Fig. 6 is similar to the one shown in Fig 4, except that the bending-up begins sooner. It requires less roll length, but the grinding effect due to difference of roll velocities is greater. The passes shown reveal the bumps which are necessary for the protection of the edges.

In the next installment, detail investigations of passes will be given for the different methods, calling attention to the many requirements which are to be met in the successful design of structural passes.

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† The action of the rolls can be considered in a very different manner, which, however, leads to the same result. It may be said that the pressure on the inclined faces has a tendency to pull the web in the right-and-left direction. This pull produces lateral contraction, which partly counteracts the elongation by direct pressure. Hence, the web is not elongated as much as it would have been, if there had been no right-and-left pull.

Developments of the Electric Skip Hoist

Description of Type of Bell Hoist Now in Use—Discussion of New Type Recently Developed—Comparison Between Direct Current and Alternating Current Blast Furnace Hoists.

By DAVID L. LINDQUIST.

Before entering into the comparison between direct-current and alternating-current furnace hoists in regard to their operation, reliability and maintenance of service, it may be of interest to describe the type of bell hoists now in use and also a new type of machine which has been developed for bell hoist service.

The introduction of the electric-driven furnace hoist has made it desirable to use an electric bell machine operating automatically in conjunction with the furnace hoist machine, resulting in uniform and automatic operation for any desired sequence of charging the furnace.

The use of electric machine, however, is not limited to bell operation only but can be employed to automatically operate the gas slide and large bell in conjunction with the furnace hoist machine.

The automatic operation of the bell hoist machine where two bells, located at the furnace top are used, is obtained in the following manner:

The small bell machine is operated by means of a contact on the furnace hoist machise.

Immediately after the furnace hoist machine has started, a contact is made by the stop-motion switch. This establishes a circuit which starts the small bell machine so as to open the bell, automatically reverses and close the bell. This stop-motion switch contact cannot be operated again until the machine has started the other bucket on its up trip. This arrangement permits stopping the main hoist and bringing the ascending bucket to its starting position, without resulting in an additional small bell operation.

Just before the small bell closes a contact on the bell machine is made which operates a sequence switch on the large bell controller. This switch is provided with a ring having contacts so arranged as to correspond to the desired charging cycle.

Each controller is electrically inter-locked so that only one bell can be operated at a time. One or more extra skip loads can be added to the furnace burden without affecting the automatic sequence. Likewise each bell can be operated independently of the auto-

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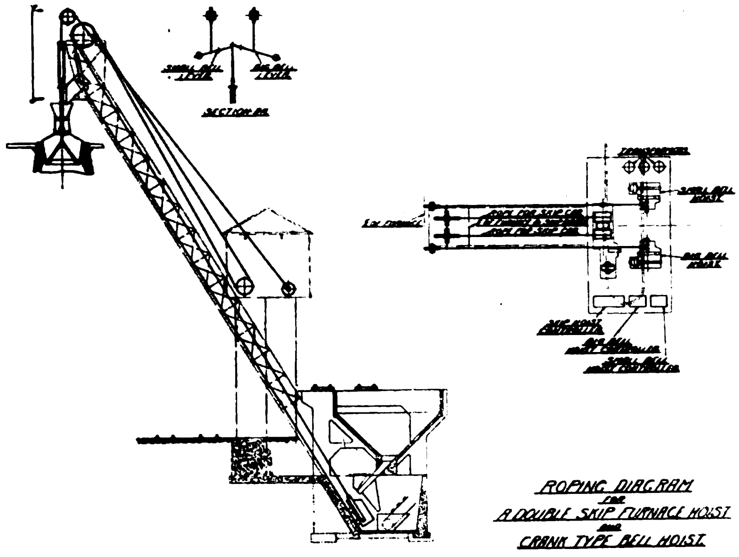
Second installment of paper read by the author before the Pittsburgh section of the A. I. S. E. E.

matic arrangement by means of push buttons without altering the sequence.

The furnace and bell hoist equipment, therefore, can be arranged to give automatic operation of the bells for practically all desired sequence of charging the furnace.

Crank Type Bell Hoist Machine.

The type of electric machine that has been quite generally employed up to the present time for bell operation, has made use of a crank to operate the bell lever. Fig. 1 shows a rôping diagram for a crank type bell hoist and double skip furnace hoist. The crank is driven by means of an electric motor through suitable gearing and the machine is provided with a magnet brake and a stop-motion device. The operation of the machine is governed by a magnet controller providing an automatic operation as just described.



ROPING DIAGRAM
FOR
A DOUBLE SKIP FURNACE HOIST
AND
CRANK TYPE BELL HOIST

Fig. 1.

Diagram 1 on Fig. 2 indicates the arrangement of bell lever and counterweight generally used. The counterweight must be of sufficient amount to overbalance the weight of the bell, bell rod and maximum charge by from 5,000 to 10,000 pounds, which makes a seal between the bell and hopper.

The bell is opened by turning the crank through one-half of a revolution and is closed by turning the crank through the remaining half of its revolution. The throw of the crank must equal the travel of the rope at the point where it is attached to the bell lever, plus the allowance necessary to make for rope stretch and rope sag.

There are many disadvantages which result from using a crank machine with the roping and counterweght arrangement just referred to which may be stated as follows: 1. The travel of the bell cannot be altered because it depends on the motion of a crank having a fixed radius. 2. The crank radius must be made greater than actually required if there were no rope stretch and sag. Theoretically, the crank should complete one full revolution when the bell strikes the hopper. Actually, the bell seats before the crank completes its revolution because of allowance made in the crank radius for rope stretch and sag. The use of a crank, involving translation from a circular to a straightline motion, is not as advantageous an arrangement as can be employed. 3. Probably the most important consideration for uninterrupted operation of the bells is, that the apparatus be designed to take care of an abnormal condition without breaking down. If a lump of ore sticks between the bell and hopper and an attempt is made to close the bell, the crank will continue to revolve, developing slack rope. Meanwhile, the bell has stopped and if the ore is suddenly crushed or falls out, the weighted end of the bell lever will drop. This subjects the machine and furnace top to a heavy blow, resulting in possible damage to the furnace top and to the machine. If the obstruction remains, the bell will stay open, requiring emergency operation of the machine to clear the bell. 4. A sufficient amount of counterweight must be provided on the bell lever to obtain a seal between the bell and hopper. As this weight is fixed on the lever, it must always be raised and lowered by the machine throughout the entire stroke of the bell, although the weight is only required to obtain sealing pressure when the bell is closed. This arrangement makes it necesary to use a large amount of counterweight and places a heavy load on the furnace top, as well as on the bell hoisting machinery.

Drum Type Machines.

Having in mind the many disadvantages inherent with the crank type of machine and counterweight, an arrangement has been devised, making use of a lever. Fig. 3. shows a roping diagram for a drum type bell hoist machine and double skip furnace hoist. standard reversible elevator drum machine with a comparatively small amount of counterweight on the bell

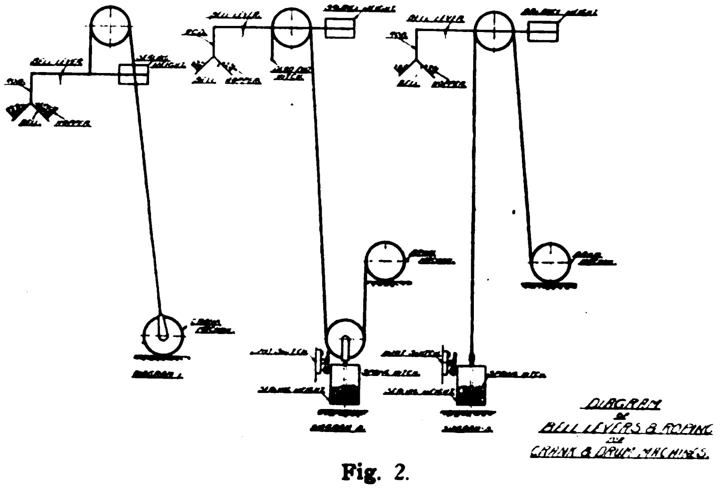


DIAGRAM
OF
BELL LEVERS & ROPING
FOR
CRANK & DRUM MACHINES.

Fig. 2.

This arrangement overcomes the numerous undesirable features of the crank type machine. To accomplish this reult, the pivoted bell lever is used with a counterweight sufficint only to balance about four-fifths of the weight of the empty bell and bell rod. A separate counterweight located on the ground or on a structure near the ground acts as a sealing weight.

Diagrams 2 and 3 on Fig. 3 indicate two of various roping arrangements used with a separate weight for obtaining a definite sealing pressure.

Reference to these diagrams will show that with the bell closed, the sealing weight is just slightly raised off its support, when it is effective for the purpose of obtaining a definite sealing pressure.

Before the bell starts to open, the machine is operated so that the rope unwinds, letting the sealing weight down on its support. As soon as this weight is down, the continued unwinding of the rope causes the bell to open, because the amount of weight on the bell side is greater than on the counterweighted side of the bell lever fulcrum. In order to open an empty bell the amount of counterweight on the bell lever must always be less than the corresponding effect of the weights of empty bell and rod in order to obtain an overbalance on the bell side. The bell is closed by operating the machine in the reverse direction, thereby winding up the rope and pulling the counterweight end of the bell lever down. During this operation, the sealing weight remains on its support because it is greater than the pull required to close the bell. This weight does not move until the bell seats against the hopper, when the continued winding up of the rope at slow speed lifts the sealing weight off its support. The instant the weight starts to move it strikes a limit switch, and opens the limit switch contact, thereby stopping the machine. This arrangement makes certain that the bell will always seat against the hopper with full sealing pressure independent of rope stretch and sag. The sealing weight is provided with a spring hitch designed to absorb any shock which may occur when the weight is picked up.

Comparison of Drum and Crank Type Machines.

A comparison of the crank and drum type machine shows the following:

The drum type machine will permit changing the opening distance of the bell by adjustment of the aumatic limit stop on the machine. This is not possible with the crank type machine.

Probably the most important consideration as already mentioned, is that the apparatus be designed to take care of an abnormal condition without breaking down.

Should an obstruction prevent the bell from closing, the sealing weight may be immediately picked up, and as soon as its limit switch opens, the controller is so arranged that the machine will at once automatically reverse, thereby opening the bell. This arrangement provides an automatic clearing of the bell under abnormal conditions with an obstruction between the bell and hopper, and gives an immediate reversal of the bell motion, which does not take place under normal conditions when the bell closes against hopper. This is a decided improvement over what happens under these conditions with a crank type machine, where an interference with the closing of the bell usually results in an open bell or damage.

From this comparison it is evident that the new arrangement of sealing weight and use of a drum machine will insure reliability of operation not possible with the crank type.

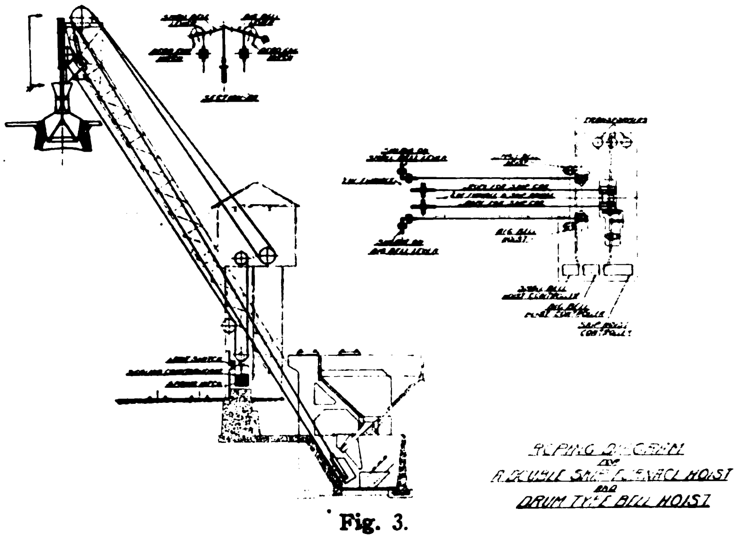


Fig. 3.

Comparison of Direct and Alternating-Current for Furnace and Bell Hoist Machines.

Having described in more or less detail the equipment comprising direct and alternating-current furnace and bell hoists, we will now make a comparison of thee two types and point out the advantages and disadvantages of each.

In considering the use of either alternating or direct-current for bell hoists, the conditions are such that there is very little preference in either case.

In considering the use of either alternating or direct-current for the furnace hoists, there are a number of important points.

The first consideration is the source of power. It may be stated that many of the blast furnace plants include in their equipment, apparatus for generating alternating-current, and the tendency seems to be toward a more extensive use of alternating-current for power purposes. Since this is the case, the use of alternating-current for the furnace hoist can be considered as an advantage over the use of direct-current.

Whenever the main power supply is alternating-current and direct-current is used for operating the furnace hoist, it is necessary to use transformers and converting apparatus, while when alternating-current is used for operating the furnace hoist, transformers only are required, and under certain conditions even the transformers may be eliminated. Any form of converting apparatus requires a machine with rotating parts, necessitating attention and consequent expense of upkeep. The principal disadvantage occurring from the use of converting apparatus lies in the fact that a shut-down of this unit causes an interruption of the furnace hoist service.

In addition, the use of converting apparatus increases the initial cost as well as the power consumption. With the transformers delta connected, a breakdown of one unit may not cause a shutdown, as the remaining units may be operated to give at least temporary service with open delta connections. If more than one transformer unit fails a shutdown will occur unless spares are available, regardless of whether the furnace hoist is operated by either direct or alternating-current.

The second consideration in the comparison is the suitability of each system when starting the hoist. Reference has already been made in detail to the starting conditions to be met. Where the conditions permit of starting and accelerating to full speed immediately, it may be stated that the alternating-current motor possesses certain disadvantages which result in greater power consumption at starting.

In the first place, the efficiency of the alternating-current motor at starting is comparatively low, as it is practically equivalent to starting a direct-current motor without any increase in field strength during starting.

In the second place, the kinetic energy of the alternating-current motor, particularly when built for two speeds is considerably in excess of that of the direct-current motor. This comparison is made still more unfavorable if the fast speed of the alternating-current motor exceeds that of the direct-current motor.

On the other hand, where the conditions require a definite slow speed for a certain distance after starting the two-speed alternating-current motor possesses distinct advantages, in that a definite slow-speed irrespective of change in load conditions can be obtained, and the alternating-current motor can run on slow speed without resistance control. With the direct-current motor, a definite slow speed cannot be obtained because the slow speed is obtained by resistance control, and is subject to excessive variation with the variation of loads.

During the time the hoist is running at full speed, neither direct nor alternating-current possesses an advantage over the other, except that additional power is required to operate the converter set for direct-current.

The third and probably the most important consideration in the comparison relates to the conditions and requirements to be met in the stopping zone. Mention has been made that accurate stopping is necessary for safe and uniform operation and this applies to all types of dumping arrangement.

In the case of the double skip the bucket should stop at the same point and with the same dumping angle regardless of whether a 3,000-pound coke load or a 15,000-pound ore load is in the bucket, otherwise the delivery of the material into the furnace top will not be uniform.

In the case of some single skips, it is necessary to have the front wheels of the carriage stop a considerable distance before the limit of travel is reached. This condition requires extreme slow speed just before the front wheels stop and a continuation of this slow speed while raising the rear end of the carriage, landing the bucket on the furnace top and lowering the bell with its charge until the final stopping position is reached.

In other cases, it may be necessary to run the hoist at an extreme slow speed as the front of the carriage approaches the goosenecks and continues to run at slow speed, while the bucket is landed on the furnace top and the loaded bell is lowered to its final dumping position.

In addition, the load on the motor may vary widely in the stopping zone, as for example, as shown on Fig. 3, the load conditions on some single skips change from a motor load, when the carriage is on the incline to a generator load when in the dumping zone and back to a motor load after the bucket has seated and the bell is being lowered to its final position.

It is evident, as mentioned before, that regardless of type of hoist or dumping arrangement used, these conditions can be met by providing a definite slow speed in the stopping zone and thereby obtain, regardless of load, satisfactory operation and accurate stopping.

In comparing the operation of the direct and alternating current motor under the conditions just outlined, we find the following:

Slow down on the direct current motor is obtained by the use of resistance control in addition to field control, and is applied automatically in the stopping zone by the stop motion switch independent of the operator. With this method of speed control, it is practically impossible to obtain a definite slow speed and accurate stop with the wide variation of loads occurring in this zone. In addition it may be mentioned that resistance control consumes a large amount of power.

Slow down of the alternating current motor is obtained by the use of the slow speed winding of the motor, and is applied automatically in the stopping zone by the stop motion switch independent of the operator. With this method of speed control, the alternating current motor, when driven above synchronous speed, will develop a definite retarding torque or dynamic braking action, due to the fact that the motor will act as a generator when driven above synchronous speed; in other words, when changing from fast to slow speed.

The Trade Paper and Its Industry

An Outline of the Service Rendered by Trade Papers—Urges Co-operation of Industry—The Mission of the Trade Paper Is to Help Industry Shape Its Course.

By BETRAM S. STEPHENSON.

Betram S. Stephenson,
M. A. Hanna & Co., Pittsburgh.

"The old theory was to print the news, just the news, and nothing more. Then the trade paper lived on its industry. The newer vision is that the trade paper has a far broader service to perform, a mission of leadership in helping the industry to shape its course. When it accomplishes this, the trade paper lives for its industry."

Not later than June 6 we shall know the tonnage of pig iron produced during the month of May. The Iron Age and The Iron Trade Review will have this information available in their issues of that date. It will have to be compiled rapidly, for the most part by wire, but it will be accurate, as may be demonstrated when the institute publishes its statistics in elaborate detail, for the six months' period.

This is but one of the many substantial services rendered by the trade papers. One regularly records ore tonnages on lower lake docks. Another, a weekly, reports coke shipments from the region. All through the summer and fall we shall trace through them the progress in the Great Lakes traffic on which this industry so largely depends. When navigation closes, within a few weeks we shall know the tonnage shipped from every mine on the Superior ranges.

These services, along with countless others, are accepted as a matter of course, for the trade press is one of the things which American industries commonly take for granted. It has been with us since the days of Bessemer and Kelly, the beginnings of bee-hive coke and the epoch-making shipment of those first few barrels of ore from Marquette. It has developed along with and as a part of the industry, which perhaps explains why we are sometimes prone to overlook its advantages and possibilities.

In describing its province, some one has said that the trade journal bears exactly the same relation to the newspaper or general magazine that the engineer or technically-trained man bears to the average citizen. It is a specialized newspaper, fitting naturally into the modern scheme of specialized business. Occasionally this specialization runs to rather curious extremes. There are such publications, for instance, as The Macaroni and Noodle Makers' Journal, the clientele of which is obvious; Brooms and Handles; The Crow Bar, which reports 4,000 blacksmiths as subscribers; Sunnyside, which is a leading publication for undertakers; even The Angora Journal, which aims to record everything of interest regarding that particular kind of goat.

A Newark library recently held a trade-journal exhibition and showed 1,200 publications without presuming to exhaust the list. "Put several hundred such publications together in a small room," commented the librarian, "and you get an effect wonderfully similar to that produced by several business men in a large room." They are dressed in varying degrees of good taste—some of them a little loud—but all of them, always and everywhere, cheerful and optimistic. This, at least, may be set down as a universal trait of trade papers.

This Newark librarian had original ideas of publicity. By his own admission he did not hope to attract many men of his own city to the exhibit. But he did figure on getting it advertised elsewhere, so that Newark men would hear from the outside world that something worth while was happening there. "That is the kind of advertising which reaches the Newark man," he observed, "even though it is a very slow process. What we are trying to do is to impress our manufacturers and business men with the amount of current information on their trades. We want to make it available for them and we want especially to foster the trade-journal reading habit."

The trade-journal reading habit! Mark Twain once remarked that he had lived in the world a long, long time and he knew one must not judge an editor by what he put in his paper. And even if we were inclined to accept the humorist's suggestion, many of us would not be in position to judge, for we have no idea what the editor does put in his paper. In fact, so far as most of us are concerned, it is hardly accurate to speak of the trade-journal reading habit, but rather of the trade-journal skimming habit. And yet our trade and technical papers, to quote Mr. Hurley, are the best in the world. They are tools of the industry and they are made to be used.

Doubtless 95 per cent of the institute members regularly see or have immediate access to the leading publications serving this special field. A goodly portion will say they are "regular readers"—and some of them are.

Paper read before May meeting of the American Iron and Steel Institute.

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But for far too many of us this reading is of only "a lick and a promise" variety. Probably on an average it amounts to a rather careful survey of a column or two of general market summary, a hurried scanning of certain special market reports in a few important centers, and perhaps a casual glance over the personal and obituary items to see whether any business acquaintances are involved in developments of a noteworthy character. Possibly some pictures may catch the eye or some special article hold the attention for a moment before the paper is tossed aside—exhausted.

This estimate is not an exaggeration. The trade papers are read somewhat more carefully in quiet times, more hastily or not at all in busy periods, but this is a fair average and indicates our general neglect of a service of which our foreign competitors show a full appreciation. Their size is awe-inspiring, it is true, some of them approaching the bulk of a mail-order catalogue. But, as a matter of fact, the weekly publications will average only about 64 pages of reading matter, because they are edited with the ever-present idea of condensation. Every line of every page is written with a view to reporting accurately some fact, condition, process or accomplishment of interest either to some special field or to the industry as a whole.

We are told that recently some 17,000 homes were visited in the course of an investigation as to the publications read by consumers in a certain district. In one particular home it was found that the publications read were THE BUTCHER'S REVIEW, THE POLICE GAZETTE and THE CHRISTIAN HERALD; furthermore, THE CHRISTIAN HERALD, in this case was read by the cook. Now the point is that these papers were read in the home, and it is perhaps pertinent to suggest here that an occasional evening spent quietly at home with your favorite trade paper, whatever it may be, will show results both surprising and profitable.

Besides the strictly technical articles, one will find there much general material of timely interest. For instance, I believe the first satisfactroy description of the Browning gun appeared in THE IRON AGE. Likewise THE FOUNDRY explained the manufacture of the improved rifle grenade which our malleable shops are now turning out by the millions. Recently a column of facts and figures in another publication, detailing the iron ore reserves of Alsace-Lorraine, Luxemburg and the Briey Basin, made clear the motive governing the direction of the first German drive in this war of steel. And these examples might be multiplied indefinitely, but the intention is merely to emphasize the appeal which the average trade paper can make even to the non-technical reader.

A year of war has re-cast business methods; it has also shifted our centers of news. During that time, as our industries have admitted Uncle Sam—first as a by-no-means silent partner and later in the capacity of managing director—Washington's position as a business news center has become supreme. The trade papers were quick to appreciate this new condition and one can now look to them for industrial-war news which is at once dependable, technically accurate and free from political flavoring. In particular, their reports of the many investigations which have stirred Washington and the country these last few months, carefully written for the business man's viewpoint, have been in refreshing contrast with the reports in the daily press. And in certain directions it is not too much to say that a careful reading of these business papers during the winter might have saved many of us from the hazards of crowded sleepers and Washington hotels.

I hold no brief for the trade journals and the idea here is not to catalogue their offerings, but rather to suggest that they merit our better acquaintance. I recall that, a dozen years ago, the owner of a small, isolated blast furnace remarked that he regularly read the several important publications touching his special field. His theory was that, if in the course of a year he could glean from them one good idea applicable to his plant, he would be well repaid. Today his furnace is the last word in equipment and efficiency and his business is highly successful. This plan of closely watching the technical press for practical, working ideas is now followed by many progressive concerns. Ordinarily it consists of a regular, systematic reading by the various executives and heads of departments. Suggestions are noted on a convenient cover slip and these are later discussed at regular conferences, frequently with the result of important improvements and economies. The plan deserves general adoption.

For many years the industry has found it convenient to use trade journal quotations as a basis for sliding-scale contracts. Pig iron and coke, ingots, billets, sheet-bars and other forms of semi-finished steel, copper and other nonferrous metals, ingot molds, even gray iron castings are among the products commonly distributed on such an arrangement. There is no means of estimating the volume of business now handled in this way, even in any one line of production, but it is always substantial and at times surprisingly large. During the chaotic price conditions of the early war period, when precedents were being swept away and new levels reached week by week, there was a very extensive recourse to this basis of dealing, as offering the only plan sufficiently flexible to conform to the feverish gymnastics of war time markets. It fitted in with Horace Greely's sage observation of us American's, that "our foresight is not so good as our hindsight by a darn sight."

Just now, because of government price control, the sliding-scale is less extensively employed; yet it is interesting to note that, even during the last calendar year, a single producer in Western Pennsylvania supplied a neighboring melter with $12,000,000 or $13,000,000 worth of pig iron invoiced on this flexible basis. When the government schedule was announced in September, the price on this sizable tonnage immediately dropped from around $55 to $36.30. The furnace interest, of course, had realized high prices much earlier than its competitors which were selling on a flat-price contract basis, hence its acceptance of the Washington scale occasioned no great hardship. The fact that the agreed prices automatically became operative on the heavy volume of products moving on sliding-scale contract was an important factor in their prompt acceptance and scrupulous observance by the entire industry.

The sliding-scale system testifies to the accuracy of trade paper quotations. Incidentally, as well, it increases enormously the responsibility of the editor. In every issue he must tabulate his ideas of current prices, whether or not they happen to be sharply defined. He knows that every variation of 25 or 50 cents immediately multiplies itself by tens of thousands of tons, to the unfair advantage or disadvantage of some one. Actually he serves in the capacity of referee or arbitrator and, in the interests of justics, should have all available information at his command. Yet too often the trade journal men find themselves compelled to pry out the facts from grudging witnesses, to content themselves with half-facts and to piece together scattered bits of obscure information in an effort to arrive at exact market conditions.

To my way of thinking, the point of view which necessitates such methods of news-gathering is radically wrong. It is an inheritence from the dark ages when, in the nature of things, every competitor was an object of suspicion and distrust. Now it is only a fair proposition that, if your business or your industry uses the trade paper quotations in this intimate way, their representatives are clearly entitled to enough of your time and confidence to put them in possession of such facts as have a direct bearing on the current market. For obvious reasons, there are always certain developments on which publicity is out of the question. But the biggest men in the industry came to realize, a long while ago, that the trade press would respect their confidence absolutely. And they learned, as well, that the representatives of these papers would welcome a knowledge of facts, which, while they could not be printed, still could be kept in mind in shaping quotations on which they had a bearing. In these latter days the industry has come to regard the trade paper man as one gifted, not with a fine sense of rumor, but with a finely-developed sense of honor and discretion.

It naturally follows, thus indirectly, that the buyer or seller who imparts either information which is untrue or half-facts which mislead by reason of what they do not tell—this with the idea of manipulating quotations—should be set down as one whose methods of trading should very properly be watched.

Our entrance into the war opened up to the business papers of the country a new field for substantial service. On the first two Liberty Loans they contributed more than 7,000 pages of advertising and editorial matter. Late in November the secretary of war sought their assistance in recruiting mechanics and skilled workmen for the Aviation Section of the Signal Corps. Only a few weeks then remained until the draft became effective, and the War Department intimated it would be well satisfied with 12,000 men before that time. The number actually secured was around 43,000.

Early last summer the War and Navy Departments were in urgent need of machine designers. A four months' search had produced 40 and the task was then delegated to the editor of the THE AMERICAN MACHINIST. Visiting some 17 machinery manufacturing centers, in 12 days he rounded up over a hundred designers and persuaded their employers, not only to loan them to the Nation, but also to pay the difference between their former salaries and the government limit of $1,800 per year.

It is also worthy of note that the far-famed Liberty motor had its origin in a trade paper idea. An automobile journal sent a representative to France and England to study aeroplane motors. He found some 30 types in use. Parts were not interchangeable and men familiar with one type could not operate the others. Astounded at the confusion and loss of efficiency, the editor laid these facts before the proper authorities at Washington, suggesting that America should concentrate on one standardized type. The Liberty motor was the result.

Regiments of road-builders, miners, railway operatives, quarry-men and lumber-men—to mention only a few—have been recruited largely through the efforts of the trade papers in their appropriate fields.

A year of war has nationalized American business. It has brought a new ideal to dominate our industrial life. It has discarded the old-time considerations of profit and competition and has substituted a new-found incentive which is infinitely bigger. Its demands have speeded up the development, manufacture and trade, so that revolutionizing changes are now made, not in decades, but almost in days.

Along with these new conditions, the war has created a difficult situation in which a diminishing labor supply faces an imperative need for increased production sufficient to offset the things consumed and destroyed in carrying on the conflict. While it is on, and when it is over, when we enter that coming commercial struggle which some one calls "the war after the war," the measure of efficiency will determine the success of any business or any industry. And greater efficiency, as a well-known editor has suggested, necessarily means closer as well as keener interest in the experiences of others, livelier appreciation of new ideas, inventions and readjustments of methods. These constitute the very merchandise traded in by the business papers.

A few months ago a convention of trade journal publishers was held in Chicago. It was featured by an exhaustive discussion of the editorial side of their business, and running all through it we find special emphasis laid on what is termed "the creative idea in editing." "Sitting in an editorial sanctum is a worn-out method," said one of the speakers. "Business papers are now best edited from the field, and preferably in the shirt sleeves."

The Time Effect in Tempering Steel

Tests on Rifle-Barrel Steel Illustrating That Time of Reheating Increases Ductility, Toughness, Machinability—Excellent Physical Properties Obtained With Steel of 1 to 1½ Per Cent Manganese.

By A. E. BELLIS,
Metallurgist, Springfield Armory.

The time effect in reheating certain steels below the critical range is very marked. The increased toughness, shock-resisting power, and machinability of steel subjected to a long, high drawing temperature has been thoroughly demonstrated and is of practical importance, particularly in the manufacture of "smokeless" rifle-barrel steel.

The time effect in tempering is most important when a maximum drawing effect is desired, in which case maximum physical properties as well as ease of machining are important considerations. These are the conditions in drilling a rifle barrel. A hole, 0.30 inch in diameter and 24 inches long for the Springfield rifle, and 30 inches long for the Russian military rifle, has to be drilled in the heat-treated material. This barrel-drilling operation is probably the most difficult one in rifle manufacture, and anyone who has been connected with rifle manufacture knows how seriously production is affected when "hard" or ununiform steel for barrels is encountered. The importance of high physical properties (tensile strength, toughness and resilience) in a rifle barrel is obvious.

The physical properties of two different lots of barrel steel are given below. The first lot, No. 1, gave serious trouble in the drilling operation. The second gave no trouble at all.

	No. 1	No. 2
Elastic limit, lb. per sq. in..........	117,450	116,800
Tensile strength, lb. per sq. in.....	132,500	131,750
Elongation, per cent...............	16.0	20.0
Reduction of area, per cent.........	42.1	51.0
Impact strength, ft.-lb. per sq. in..	450.0	520.0

This difference in machining and physical properties was due entirely to the time of reheating. The first lot was given a reheating time of 30 minutes, the second lot remained at the reheating temperature two hours. Both lots had been oil quenched from 1,500 deg. F. and reheated to 1,180 deg. F. The time required in the reheating or drawing for the work to come to temperature was not counted. This time was approximately 20 to 30 minutes. The steel used has the following composition: carbon, 0.54; sulphur, 0.050; manganese, 1.22; phosphorus, 0.065.

The physical properties when untreated are as follows:

Elastic limit, lb. per sq. in..................	69,800
Tensile strength, lb. per sq. in..............	128,700
Elongation, per cent.........................	15.0
Contraction, per cent........................	35.2

The critical range is shown in the curve.

Further experiments established the fact that at least a two-hour reheating is necessary in order to have satisfactory machinability. Steel which, after treatment, gave elongation of 20 per cent, or over gave no trouble in the shops. These results were backed up by hundreds of physical tests and production reports on thousands of barrels.

A similar test with different heat lots of steel indicates that greater increase in machinability, ductility, and resilience can be obtained by making the drawing time still longer. The results of this test with drawing periods of one, two, and three hours; follow, together with the results of another test made with drawing periods of one-half hour and 12 hours. The latter test was made with the idea of producing the maximum time effect.

	Reheating time				
	1 hr.	2 hr.	3 hr.	½ hr.	12 hr.
Elastic limit, lb. per sq. in	124,250	121,600	116,250	115,500	98,750
Tensile strength, lb. per sq. in.........	137,000	135,600	125,900	135,400	116,500
Elongation, per cent	17.0	17.5	19.0	17.5	22.0
Reduction of area, per cent	42.2	45.4	47.6	52.7	57.2

It will be noted that there is a decrease in the elastic limit and tensile strength as the drawing time is increased, but that this is slight compared to the relatively great increase in ductility and impact strength. The decrease of elastic limit of less than 1 per cent is accompanied by an increase of 25 per cent in ductilitv as measured by elongation, and 13 per cent increase in impact strength.

In order to determine whether this effect was largely due to the high manganese content of the steels, an ordinary machining steel of the same carbon content was given a similar test. The steel analyzed: carbon, 0.53; sulphur, 0.036; manganese, 0.65; phosphorus, 0.049.

Four specimens were oil quenched from 1,500 deg. F. and drawn at 1,180 deg. F. for periods of one-half, one, two, and four hours, respectively. The results follow:

	Reheating time			
	½ hr.	1 hr.	2 hr.	4 hr.
Elastic limit, lb. per sq. in......	66,150	63,800	62,750	61,600
Tensile strength, lb. per sq. in.	101,250	98,250	97,250	96,600
Elongation, per cent...........	23.0	26.0	28.5	28.5
Reduction of area, per cent....	60.8	67.5	65.0	65.8

(Continued on page 279)

Paper presented before A. I. M. E., New York, February, 1918.

PRODUCTION TOPICS

THE MONEY LOST UP A CHIMNEY.

A handy and useful chart has been developed by the Uehling Instrument Company, 71 Broadway, New York. It is of unusual interest and value at the present time when the coal problem is so important, for it enables anyone to quickly and closely estimate the money now being lost up almost any chimney due to low CO_2.

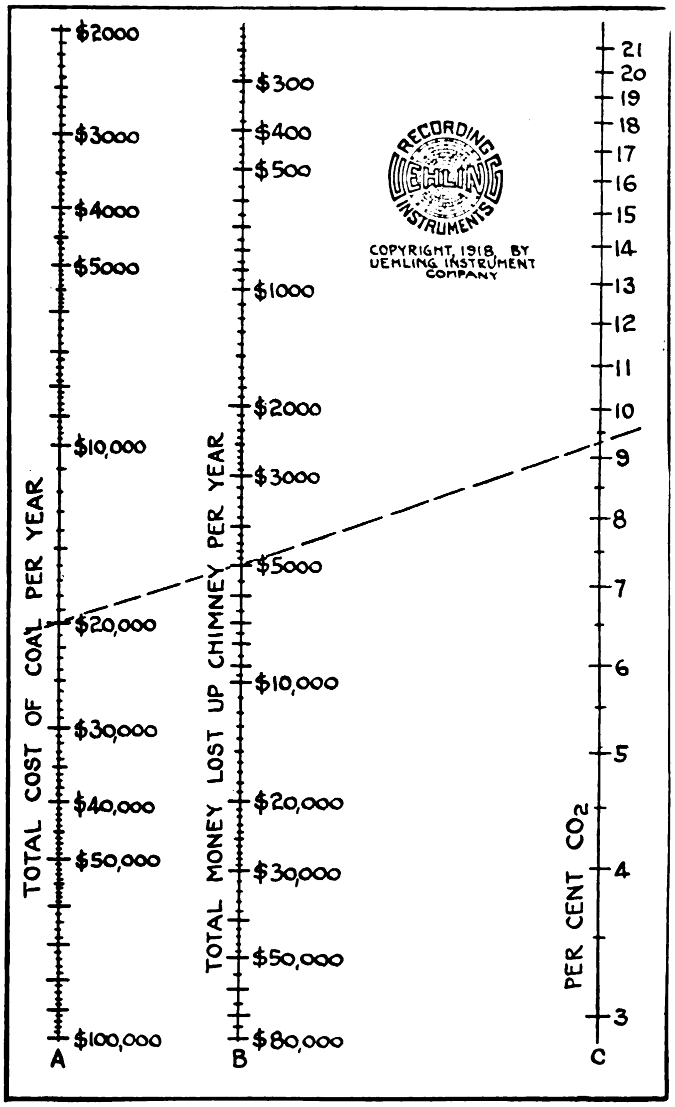

Chart for estimating money lost, due to poor combustion.

Simply connect the percentage of CO_2 (shown in column C) with the money now being spent per year for coal (shown in Column A), and the intersection of the connecting line with column B immediately gives the dollars rolling out of the chimney in the form of heated gases.

Example: If $20,000 is spent per year for coal burned in a furnace whose average CO_2 registers 9.3 per cent, what is the approximate money lost up the chimney per year?

Solution: Connect the $20,000 (column A) with the 9.3 per cent (column C), as indicated by the dotted line drawn across this chart, and the intersection with column B shows the approximate yearly loss to be $5,000.

The object of this chart is to show that a high per centage of CO_2 is most desirable. To be sure, even where the CO_2 is as high as 21 per cent, the theoretical maximum, there is a loss because in the average power plant the flue gases leaving the boiler have a temperature as high as 500 or 600 deg. F. Loss, therefore, is inevitable unless a blower is used for exhausting the gases and some sort of interchange system is installed for either heating the feed-water or preheating air and leading it under the grate.

It is well to know all about these various things and the Uehling Instrument Company advises that its engineers will gladly coöperate in whatever way possible with responsible concerns to secure maximum returns from every dollar invested in coal. Being combustion specialists, the advice of the Uehling people will be of particular value in showing how to attain the highest possible percentage of CO_2. It should be borne in mind that combustion is a chemical process and for that reason should be studied from the viewpoint of the chemist.

It is significant that most of the large power plants of to-day have adopted CO_2 instruments that record automatically and continuously. The reason for this is to keep constant tab on the workers in the boiler room and the efficiency of combustion. The recorder may be placed at any convenient distance from the boiler in the office of the chief engineer, owner, manager or superintendent, while an auxiliary CO_2 indicator is placed on the boiler front in full view of the fireman. The function of the indicator is to keep the fireman constantly informed as to the efficiency of his own work. This feature is most commendable.

Coal cannot be saved by a CO_2 machine alone. If no attention is paid to the indicator or recorder, the installation of such apparatus borders on foolishness. The records should constantly be made in firing methods until the best percentage of CO_2 is obtained. After the best mark is reached, fluctuation of the CO_2 line below that mark to any great extent should not be allowed.

This chart is based on a flue gas temperature of 600 deg. F., and an outside air temperature of 60 deg. F. Where the flue gas temperature is higher, or the outside air temperature lower, the money loss will be correspondingly increased. On the other hand, with a higher outside air temperature and a lower flue gas temperature, the money loss is proportionately decreased. Further, in the construction of this chart, it has been assumed that the coal has a calorific value of 14,500 B. t. u. per pound of combustible.

It may also be interesting to point out that where there is only 3 per cent of CO_2 in the flue gases, 76 per cent of the heat value of the coal passes up the chimney as waste under the conditions outlined above. It is impossible, however, for these gases to contain as low as 2 per cent, because it would require more than the original quantity of heat in the coal to heat the enormous surplus of air to a temperature of 600 deg. F.

ERRATUM.

The Blast Furnace and Steel Plant wishes to correct an error which appeared in the May issue. On page 201, the article on "Liquid Ferro-Manganese in Open Hearth," signed by E. C. Hummel as superintendent electric furnaces, United Alloy Steel Corporation, should have been signed as superintendent, electric melting furnaces.

NEWS OF THE PLANTS

NEW ORDNANCE PLANT AT PITTSBURGH.

Under the direction of the organization to be known as the United States Steel Corporation Ordnance Department, a proposed gun and projectile plant is to be built on Neville Island, Pittsburgh, Pa. The number of units comprising the steel works, blast furnaces, etc., have not been determined as yet. That the plant is to be of considerable size is certain, inasmuch as a real estate company is contemplated to lay out a town embracing municipal buildings, several hundred houses, parks, playgrounds, etc., similar to Gary, Ind. The ordnance plant will occupy approximately 400 acres, and 600 acres will be used for storage and for homes for employes.

The organization consists of a general committee comprising the following members: John Reis, vice president of the United States Steel Corporation, chairman; Homer D. Williams, president of the Carnegie Steel Company; William J. Filbert, comptroller of the United States Steel Corporation; Taylor Allderdice, second vice president of the National Tube Company; August Ziesing, president of the American Bridge Company; G. C. Thorp, vice president of the Illinois Steel Company; William Wigham, third vice president and chief engineer of the Carnegie Steel Company; C. L. Miller, vice president and general manager of the American Steel & Wire Company; W. B. Schiller, president of the National Tube Company, and George G. Crawford, president of the Tennessee Coal, Iron & Railroad Company.

The following will have direct charge of the construction and operation of the new plant: John S. Oursler, general superintendent of the New Castle and Sharon, Pa., blast furnaces and steel works of the Carnegie Steel Company, general manager; F. W. Waterman, manager of the National Tube Company's works at Gary, Ind., assistant manager; L. E. Thomas, chief engineer of the same plant, chief engineer; George Brown, now in the purchasing department of the National Tube Company, Pittsburgh, purchasing agent; R. C. Cochran, traveling auditor of the American Sheet & Tin Plate Company, auditor.

John Hulst, chief engineer of the United States Steel Corporation; P. C. Patterson, chief engineer of the National Tube Company, and J. L. Barnard, chief engineer of the American Bridge Company, have been appointed to work with the general committee. An office to be used as headquarters has been established in the Union Arcade Building, Pittsburgh, Pa.

The United States government will probably buy or condemn all the property on Neville Island. Dealings will be conducted directly with the owners of the property, and if exhorbitant prices are charged the land will be acquired by condemnation and adjustment made in the Federal courts. The plant will be built for the government and operated by the United States Steel Corporation.

NEW BY-PRODUCT COKE OVENS.

H. Koppers Company announces that it has been awarded a contract by Jones & Laughlin Steel Company for the construction of a by-product coke plant of 300 ovens. This plant will have a carbonizing capacity of approximately 2,000,000 tons per year and will replace beehive coking capacity to that amount. The plant will be complete in every respect and will be equipped for the recovery of ammonia in the form of ammonium sulphate, of tar and of benzol and toluol as pure products. The ammonium sulphate and pure toluol from this plant will be sold to the government for war purposes. The steel company proposes to use the gas in its steel plant operations.

It has also been recently announced that H. Koppers Company are to build two more batteries of by-product ovens for the plant of the Steel Corporation, at Clairton, Pa. This will give the Steel Corporation a plant of 748 ovens which, when completed, will be the largest by-product coke plant in the world.

The plant of the Illinois Steel Company, at Gary, Ind., which has recently added 140 Koppers' ovens to its original installation of 560 ovens, is at present the largest by-product coke oven plant in the world.

Announcement has been made in the papers of the incorporation of the Fairmont By-Products Corporation, of Fairmont, W. Va. This company has been formed to build and operate a by-product coke plant. A contract has been given to H. Koppers Company for the construction of a plant to consist of 110 ovens, with the necessary boiler plant and accessories.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF
The Blast Furnace and Steel Plant

[Required by the Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant,** published monthly, at Pittsburgh, Pa. [Report for April 1, 1918.]

Publisher—National Iron and Steel Publishing Company, 108 Smithfield street, Pittsburgh, Pa.

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R. E. Densmore, 612 Union Trust Building, Detroit, Mich.
Mary A. Howe Estate, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

ADAM W. TRITSCH, Business Manager.

Sworn to and subscribed before me this 21st day of March, 1918.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1919.)

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W. S. S. WORTH $5.00 JANUARY 1, 1923

Some Pointers on By-Product Coke Oven Operations

QUALITY OF COKE.

By W. H. Blauvelt.

In the discussion of this subject I shall not go into the chemical composition of coke, since the permissible amount of any impurity for a given use is well understood, and the different elements are easily determinable. The physical structure of the coke is quite as important as its chemical composition. It is the physical structure which gives coke its advantage for metallurgical work over other forms of solid fuel, and it is important that the structure should be adapted to the conditions under which the coke is to be used.

The blast furnace is the great coke consumer. In the days of the beehive oven one kind of coal gave a coke with a certain physical structure, and another coal gave another structure. Furnaces either adapted their practice to the coke, or changed their coke supply. Coke was recognized as hard or soft, porous or dense, and that was about all that was known regarding physical structure.

Mr. Brassert says in his paper on "Modern American Blast Furnace Practice," read in 1914, that "the early coke produced in our by-product ovens, even from the same coals as were successful in the bee-hive oven, burned too slowly and made our furnace operations exceedingly difficult, by preventing rapid and continuous movement of the stock. The lack of knowledge and experience along these lines was responsible for the slow progress attending the introduction of by-product ovens in this country." The economy of the by-product oven practically forced its adoption by the furnace operators, and for several years, as Mr. Brassert states, "at a number of American plants by-product coke has been made which rivals in quality our best bee-hive product."

The by-product oven, with its variable mixtures of coals, variable heats, coking time, width of oven, fineness of coal charged, and other controlling factors, permits a control of coke structure formerly impossible. The problem is to determine first, what is the structure best adapted to standard furnace practice, while recognizing that special practice requires modifications of structure; second, what conditions are necessary to produce it.

Notwithstanding the general acceptance of Gruner's theory of ideal combustion in the furnace, the production of a high thermal heat at the tuyeres is of the first importance, and the best coke is that which reaches the tuyeres in proper condition to produce the highest temperatures in the tuyere area, and in just sufficient quantity to do the amount of work required there under the conditions produced at this maximum temperature.

The ideal coke is one which will descend through a furnace shaft to the combustion zone in front of the tuyeres with the least loss from attrition and oxidation, and when it arrives there will burn at the highest possible rate. Of course, these are paradoxical qualities. However, Walter Mathesius points out in his interesting paper on "Chemical Reactions of Iron Smelting" that "modern American coke-oven practice has made enormous strides toward approaching this apparently paradoxical ideal." He stated that this is accomplished by producing coke with an open-cell structure, in which the cell walls themselves are amply strong and well protected by graphitic coating.

The time of contact of the blast with the coke in the tuyere area can be only a few seconds and the speed of any chemical reaction decreases as the relative quantities of reacting and resulting substances approach equilibrium. Therefore, the farther these relative quantities remain from the status of equilibrium, the higher the rate of resultant combustion. With the facts now before us I am disposed to believe that we should, in seeking to produce the best blast furnace coke, aim to produce an open cell structure, with cell walls strong and hard. Later experience may, however, show that there are other requirements that are not now known to us. It is not necessarily true that the open cell structure is the same thing as a high percentage of cell space. The advantage of an open cell structure is that it gives the oxygen of the air easy access to the carbon. It is entirely possible that a coke of very fine cell structure, having say 50 per cent of cell space, might offer less surface for prompt combustion under practical conditions than another coke containing larger cells but having the same percentage of total cell space.

The composition of the cell wall, which it is agreed should be hard, thin and strong, and, according to Mr. Mathesius, covered with a graphitic coating that is smooth and bright, is a much more complicated matter. What are the conditions of coal mixture and coking which produce this kind of wall? I think we have not yet found the answer to this question, although we know some of the conditions that are favorable to this result. The coal mixture, the degree of fineness of grinding, the coking time, and the heats are probably all factors.

Our search for the best coke structure to meet a given set of furnace conditions is not an easy one, but we know better which path to start on than we did even a few years ago. Are we not agreed on the following points at least?

1—The coke must be hard.

2—It must have an open cell structure; that is, cells of good size and approximately 50 per cent of cell space.

3—It must have a high rate of combustibility.

Can we add anything more to this list? Some investigators have concentrated their comparisons on the rate of combustibility, but I cannot believe that this test alone is sufficient to determine the best coke structure, because it ignores one of the sides of the paradox. While the best coke must burn rapidly at the tuyeres, it must also resist attrition and oxidation during its descent in the furnace. Good-sized cells and a good percentage of cell space, coupled with a hard structure, would seem to give a coke corresponding to Mr. Mathesius' definition. Testing the rate of combustion has been a help to us, and I hope we will find a test for hardness of structure better than the crushing of the 14-inch cube speciments, over which so much time used to be spent in the days when John Fulton wrote his book on "Coke."

Foundry and Domestic Coke.

In addition to the iron blast furnace, foundry cupolas afford a steady market for coke, and in recent years the domestic market has grown to importance. Before the war, sales of coke for domestic use amounted to over 1,500,000 tons per annum, although these sales really rather demonstrated the value of coke as a domestic fuel than showed what were the ultimate possibilities of the trade. Foundry coke is usually made on a somewhat slower coking time than furnace coke, as cupola practice calls for larger and tougher pieces.

The production of domestic coke is now a greatly different industry from what it was in earlier days, when most of the domestic coke was produced in gas works. At that time it was often regarded as something to be got rid of with the least trouble, rather than as a regular and important source of income to the works.

Third installment of paper read by the author before A. I. M. E. meeting, New York, February, 1918.

INDUSTRIAL SAFETY

THE PROGRESS AND POSSIBILITIES OF ACCIDENT PREVENTION WORK.

By Marcus A. Dow.

In the year 1910, on all of the railroads, 2.17 employes were killed out of every thousand men employed, while in 1916, only 1.17 were killed out of each thousand employed— a decrease of 47 per cent in the number of employes killed per thousand employed. In 1910, 47.1 employes were injured per thousand employed on the railroads, while in 1916, only 25.2 were injured per thousand employed, a decrease of 46 per cent in the number of railroad men injured per thousand employed. There are many splendid records made by individual roads, and pride in the accomplishment of those who have worked with me on the railroad I have the honor to represent prompt me to tell you that on the New York Central Railroad in the year 1916, as compared with 1913, there was a decrease of 35 per cent in the number of employes killed per million tons freight carried one mile, and a decrease of 20 per cent in the number of employes injured per million tons freight carried one mile. Actually, in the three years ended December 31, 1916, on this road 284 employes were saved from fatal injury and 6,211 from non-fatal injury, using the injury rate for 1913 as a basis and comparing subsequent yearly rates therewith and including only injury cases where more than three days was lost from work. I wish that I but had the time to give you in detail the record of successful results in the long list of railroads which, through their safety work, have made reductions of equal merit, beginning with the Chicago & Northwestern Railway, the first railroad to inaugurate a safety campaign, and which in 6½ years has saved the lives of 293 of its employes, and including all cases of more than one day's disability, has prevented 15,769 from getting injured, through the humanitarian work of that grand old safety pioneer, Ralph C. Richards. But out of fairness to the industries, I must leave the railroads and tell you briefly what has been accomplished in some of the big industrial plants where safety has been made the first consideration, and the lives of their employes are considered the most valuable asset they have. The record of the United States Steel Corporation stands out like a beacon light to dispel every vestige of doubt and uncertainty. The record of this corporation shows that in the nine years ended 1915, its safety work has saved 14,967 of its employes from death or serious injury, the injury rate for 1906 being used as a basis, and comparing subsequent yearly rates therewith, and including as injuries cases where more than 35 days' time was lost from work. A careful record has been kept of the amount expended in carrying on its safety work, and it has been found that through the reduction of its casualty settlements it received back all it spent in safety work, and, in addition, a sum equally as great, and totalling millions of dollars. The long list of industrial concerns, with similar records of achievement, should have their names emblazoned in a roll of honor that would inspire and enlighten the world. There is the E. I. Du Pont de Nemours Company, with a record of 9.17 employes killed per thousand employed in the year 1908, but showing a steady decrease, until in 1916 there were only 2.41 employes killed per thousand employed. There is the Eastman Kodak Company, with their reduction of nearly 67 per cent in the number of accidents to each thousand employed in 1916 as compared with 1912, while from a record in the office of the National Safety Council, I have taken a list of industries showing records of accident prevention since the commencement of their safety activities that are actually astounding, and should convince the most sceptical that there is indeed a wonderful opportunity to serve humanity and to benefit industries by persistent accident prevention work. In this list are included:

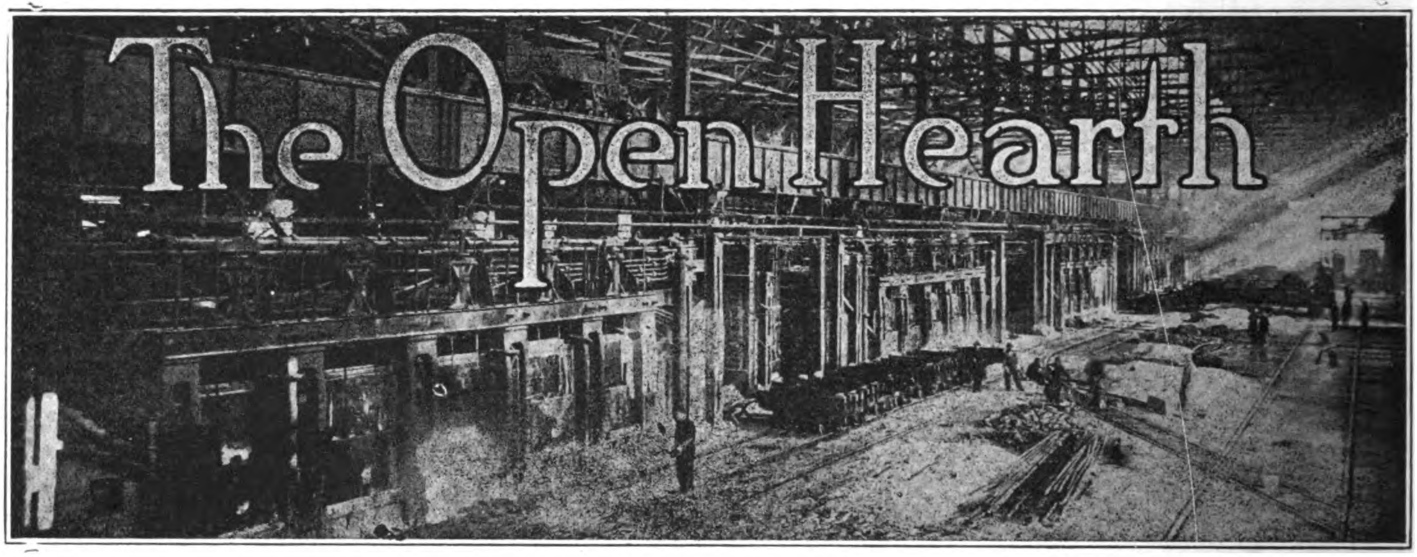
	Decrease
The American Smelting & Refining Company..	24%
Cadillac Motor Company	69%
Commonwealth Edison Company..............	40%
Commonwealth Steel Company.................	69%
Corn Products Refining Company..............	37%
Fairbanks-Morse Manufacturing Company.....	72%
Harrison Brothers & Company.................	75%
Illinois Steel Company.........................	85%
Inland Steel Company....-....................	35%
International Harvester Company..............	88%
Milwaukee Coke & Gas Company..............	83%
Neenah Paper Company........................	83%
Packard Motor Car Company..................	72%
Pullman Company	46%
Rochester Railway & Light Company..........	33%

These are but a few of the many concerns that have proven by their deeds that safety work pays.

I should be inexcusably remiss if I did not say a few words in recognition of the splendid services rendered this movement by those two genuinely helpful organizations, the American Museum of Safety and the National Safety Council. The museum, with its collection of devices and models of safety and sanitary appliances, its library of books and reports, photographs and lantern slides, illustrating the most practical methods of protecting life and health, has been of material assistance to those seeking knowledge of the principles of life conservation. The growth of the National Safety Council has been most phenomenal. Even the most optimistic of that little gathering of engineers in Milwaukee, in the early fall of 1912, who launched the first National Safety Congress ever held in the United States, had little idea that out of that gathering would grow one of the greatest coöperative organizations for human betterment that the world has ever seen. Beginning in a small way with a handful of members, pledged to the promotion of safety to human life in the industries of the United States, this non-commercial association of unselfish business and professional men has grown in a few short years to an organization composed of 3,400 members, employing more than four and one-half million workmen. Its income, derived entirely from the dues of its members, is now approximately $100,000 per year, every dollar of which is judiciously expended in providing actual service to its members. Through its central office, 5,000,000 safety bulletins are distributed each year, and these bulletins, together with other forms of literature sent to its members, serve to educate both employer and workmen as to the simplest methods of preventing accidents. Its original plan was to confine its efforts to the prevention of industrial accidents, but through an irresistible force it has attracted to its emblem men and women from every walk of life, and to-day its activities include not only industrial safety, but public safety and safety in the home. Probably the most valuable of its many forms of service is through its information bureau. At its headquarters in Chicago is the most complete library of safety information in existence, and already its members are beginning to learn to take their welfare and accident prevention problems to this bureau for solution and to obtain information and enlightenment.

Third installment of paper read by the author before the Sixteenth Annual Safety Congress.

The Open Hearth



R. W. H. Atcherson

R. W. H. Atcherson is now superintendent of blast furnaces of the Inland Steel Company, Indiana Harbor, Ind., succeeding James B. McClure deceased. Mr. Atcherson was born at Columbus, O., in 1880, and attended grammar and high school there. His family moved to California and he completed his high school course in 1899 and started to work in the general superintendent's office of Pennsylvania Lines at Columbus, O., and was there three years. He took up a course in mechanical engineering with International Correspondence School.

He started in the blast furnace business in May, 1902, at Bellaire works of Carnegie Steel Company and was promoted through various positions to the superintendency. Four and one-half years ago he was transferred to Clinton blast furnaces of the Carnegie Steel Company, and was superintendent there until he resigned to accept his present position at Indiana.

* * *

Gil Davis is superintending the installation of a new heating plant for the Tennessee Coal, Iron & Railroad Company. He has been superintendent of the heating department, Morledge Company, Newport, Ky.

* * *

Frank Garrett has been promoted to general superintendent of the Latrobe Electric Steel Company, Latrobe, Pa. He was formerly metallurgist. A. A. Frey succeeds Mr. Garrett.

* * *

C. J. Ramsburg, vice president of the H. Koppers Company, is now assistant to Col. G. W. Watson, having been appointed technical expert on toluol in the United States Ordnance Department.

* * *

C. Oberstadt has resigned as superintendent of the Cleveland plant of the Elyria Iron & Steel Company, Elyria, O.

* * *

John S. Oursler has been appointed general manager of the construction of the gun and ordnance plant at Neville Island. Mr. Oursler has been associated with the steel industry all his life. Since 1896, when he was made blast furnace superintendent, of the New Castle works of the Carnegie Steel Company, he has also been blast furnace superintendent at Mingo Junction, at the Ohio blast furnaces at Youngstown and again at New Castle. Since 1907 Mr. Oursler has been general superintendent of all the steel works and blast furnaces of the Carnegie Steel Company, at Sharon, Farrel and New Castle, Pa.

* * *

Wilbur B. Driver, former vice president of the Driver-Harris Company, has retired from active business.

* * *

George H. Charls will be connected with the Berger Manufacturing Company, Canton, O., having resigned from his position as vice president and manager of sales of the American Rolling Mill Company, Middletown, O.

* * *

Roy S. Bruner, formerly in the engineering department of the Bethlehem Steel Company, has been appointed general manager of the Hamilton-Otto Coke Company, Hamilton, O., following the resignation of E. M. Peters.

* * *

John H. Meyers has been promoted to superintendent of the bridge department of the Steelton plant of the Bethlehem Steel Company. He succeeds Carl B. Ely, who is in the aviation division of the Signal Corps of the United States Army.

* * *

Clyde Brooks, formerly secretary and manager of the Pittsburgh Iron & Steel Foundries Co., is now devoting his time to civilian government duties in Washington. Before becoming associated with the Pittsburgh Iron & Steel Foundries Co., he was connected with the Schoenberger works of the American Steel Company. Later he was assistant to the vice president and general manager of the Midland Steel Co.

* * *

P. T. Reese has resigned as plant manager of the Superior Steel Corporation, at Carnegie, Pa., and is now associated with the Driscoll-Reese Steel Company, Hamburg, Pa., manufacturers of electric steel castings.

* * *

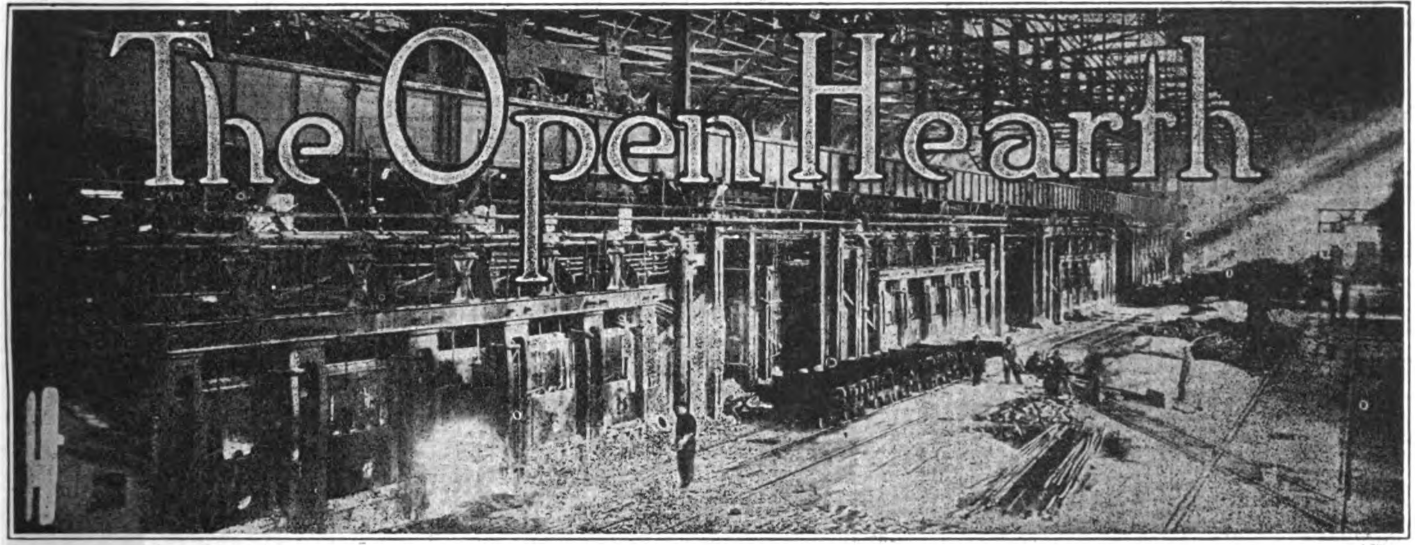
W. S. Raudenbush is now manager of the Juniata Furnace & Foundry Company, Newport, Pa., succeeding R. M. Marshall, who is now in the United States tank service.

* * *

L. M. Hartzell, formerly manager of the Bessemer department of the Homestead plant of the Carnegie Steel Company, is now assistant manager of sales of the Carnegie Steel Company, at Cincinnati, O.

* * *

F. P. Burgoyne is now connected with the Modern Iron Works, Lima, O., as factory superintendent.



The Open Hearth

E. W. Young has become assistant superintendent in charge of by-products of the Northampton plant of the Bethlehem Steel Company, succeeding W. Seymour resigned.

V V

J. A. Beatty has been made assistant superintendent of the oven section of the Bethlehem Steel Company's Northampton plant. His former position as general foreman has been taken by R. L. Martin.

V V

William L. Hoffman has again resumed his work at the Washington office of the Brier Hill Steel Company after an extended illness.

V V

H. G. Flury, formerly with the American Bridge Company, at Gary, Ind., is now connected with the Kansas City Structural Steel Company, Kansas City, Mo.

V V

Capt. James E. Ferguson, president of the Ferguson Iron & Steel Company, Buffalo, N. Y., will be in the naval construction section of the Navy. He was formerly in the aircraft production branch of the Signal Corps of the Army.

V V

David Bradley Carse has opened an office in the Oliver Building, Pittsburgh, Pa., as an industrial engineer. He was formerly a member of the advisory committee of the United States Steel Corporation.

V V

At the annual business meeting of the American Iron and Steel Institute held in May, the following directors were reelected for the three-year term ending 1921: James A. Burden, James A. Campbell, Thomas Cantley, Eugene G. Grace, William A. Rogers, J. F. Welborn.

Col. Maben retired from the board on account of ill hearth and Thomas K. Glenn, president of the Atlantic Steel Company, Atlanta, Ga., was elected to succeed him.

V V

George M. Verity, president of the American Rolling Mill Company, has been appointed president of the committee in charge of camp welfare houses at Camp Sherman. James A. Campbell, president of the Youngstown Sheet & Tube Company, is also on this committee.

V V

Stuart B. Marshall is now consulting engineer, chemist and metallurgist on blast furnaces, coke ovens, foundries, ferro-alloys, ores, etc., at Roanoke, Va. Mr. Marshall was formerly connected with the American Manganese Manufacturing Company, Dunbar, Pa., and the Aluminum Company of America.

V V

Brig.-Gen. Tracy C. Dickson is now at the Bethlehem Steel Company, South Bethlehem, Pa., in connection with ordnance work.

V V

J. W. Weinland is connected with the Chicago office of the Liberty Steel Products Company. He was formerly with the American Steel Foundries.

V V

William G. Mathias, who has been general superintendent for the past several years of the Tennessee Coal, Iron & Railroad Company, at Ensley, Alabama, has been appointed assistant to the vice president. Karl Landgrebe succeeds Mr. Mathias.

V V

C. J. Barr, formerly general superintendent of the Fairfield works of the Tennessee Coal, Iron & Railroad Company, is now assistant to the vice president of the Fairfield Steel Company, Birmingham, a subsidiary of the Tennessee Coal, Iron & Railroad Company. G. A. Miller will take the position vacated by Mr. Barr, who is also assistant to the vice president of the Chicksaw Shipbuilding Company, also a subsidiary.

V V

M. L. Lothrop, previously in charge of the steel and tube department of the Timken Roller Bearing Company, Canton, O., has been promoted to assistant factory manager.

V V

M. C. Robbins having purchased stock of the Progressive Age Publishing Company, publishers of the "Gas Age" and "Brown's Directory of American Gas Companies," has resigned as general manager and director of the "Iron Age." He will be president and treasurer of the Progressive Age Publishing Company.

V V

A. W. Allen, formerly superintendent of the open hearth furnaces of the Ensley works, Tennessee Coal, Iron & Railroad Company, has been appointed assistant general superintendent, Ensley works.

V V

Bent L. Weaver will take charge of the locomotive plant of the Vulcan Iron Works, at Wlikes-Barre, Pa. He was formerly superintendent of the steel foundry department, Bethlehem Steel Corporation, Steelton, Pa.

WITH THE EQUIPMENT MANUFACTURERS

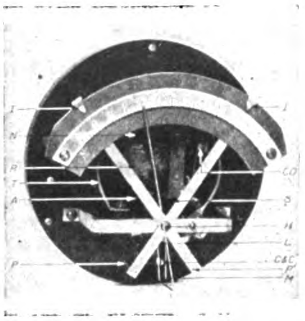
A NEW PRESSURE GOVERNOR FOR GAS AND LIQUID SYSTEMS.

In many power installations where air, other gases or liquids must be maintained under pressure, the demand for an automatic method of doing this has arisen.

As a result the General Electric Company has developed a new pressure governor to control standard self-starters for motor-operated pumps and compressors. The governor maintains a pressure between predetermined limits on any gas or liquid systems that will not corrode the Bourdon tube.

This governor is called the CR2922 and can be used on any standard AC or DC circuit. It is rated for pressures of 80, 100, 160, 300 or 500 pounds and operates within settings of from 3 to 12 pounds between high and low pressures. Governors for higher pressures can be supplied if desired.

Contact making pressure governor with internal relay for DC or AC circuits.



The internal mechanism for a CR2922 pressure governor.

The governor consists of a Bourdon tube, an indicating needle, a graduated pressure scale, adjustable high and low pressure stops to determine the desired pressure range, and a relay which actuates the contacts in the control circuit of the self-starter, all enclosed within a dustproof case, easily opened for inspection.

Action of the governor is dependent on the Bourdon tube which should be connected to an independent discharge pipe from the pressure tank. The free end of the tube "T" is mechanically connected to the indicator needle "N" moving it over the scale as changes of pressure affect the tube.

After the settings for the pressure range have been made, the governor will automatically maintain pressure within those limits. The operation of the pressure governor is as follows:

Assuming that the pressure is at the low value, as indicated by the left-hand indicator (I), the contact (C) on the needle (N) completes the circuit through the contact (C') on the movable arm (M), which at the low pressure point rests against the stop (P'). When this contact is made, the circuit is completed through the relay coil (R), causing the armature (A) to close. Attached to this is the contact (CO) which upon closing, completes the control circuit to the self-starter, causing the motor to start.

The armature is also attached to the spring (S) which holds the contact (C') firmly against (C) until contact is broken at (P).

As the pressure increases, the needle pointer moves to the right, but its lower part to which the contact (C) is attached moves to the left, and is followed by the movable arm (M). When the high pressure point is reached, the movable arm is prevented from traveling further by stop (P) and the needle continues its course, breaking the circuit by separating contacts (C and C'). The instant the circuit is broken the relay (R) is de-energized, its armature falls, releasing the tension of the spring (S) and because the movable arm (M) is counterweighted it returns to the stop post (P').

When the pressure is decreased to the minimum value, the contact (C) again completes the relay coil circuit by engaging contact (C)') and the cycle of operation is repeated.

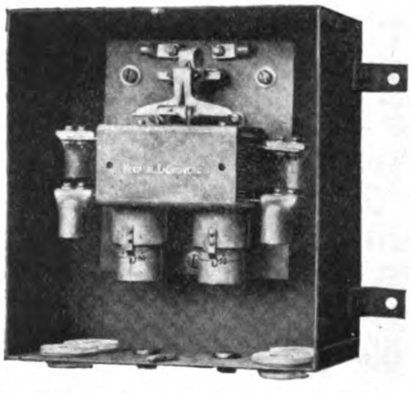
The case is tapped and drilled at the bottom for the pressure pipe and electrical conduit connections.

A SAFETY FIRST RELAY.

War time conditions demand that the utmost care be taken of both machines and men in the factory and shop. The safety first relay manufactured by the Westinghouse Electric & Manufacturing Company provides a neat, safe and efficient method of supplying overload protection for alternating-current applications equipped with starters or switches having low-voltage protection.

The relay is enclosed in a sheet steel case which excludes dust and foreign particles of all kinds. The cover of this case is secured by two thumb screws and is provided with a safety device which automatically trips the relay when the cover is removed, thus rendering all parts of the relay "dead" as long as the cover remains off, so that inspection or repairs can be made without danger.

This case is arranged for wall mounting in any convenient place near the switching equipment.



Overload relay with cover removed.

inactive at leads less than that for which they are set. When the current value reaches or exceeds this setting, the coils lift plungers which break the control circuit and operate the low-voltage relay to open the line circuit. With no current flowing in the line, the coils are de-energized and the relay is automatically reset, the bridge being pressed against the contacts by means of a compression spring.

The plungers operate in oil dash pots, providing a time element which allows the relay to carry a momentary overload without tripping.

This time limit is adjustable by means of a small perforated disc in the dash pot, which is readily accessible by unscrewing the dash pot from the casting which holds it. Turning the disc so that more perforations are uncovered lessens the time of the momentary overload; with fewer perforations the time element is increased.

These relays will operate over a wide range of current values, for which adjustments can readily be made by lowering or raising the dash pot. This is marked with a scale, and an indicator clearly shows the tripping value.

To prevent accidental change of adjustment from vibra-

WITH THE EQUIPMENT MANUFACTURERS

tion or jar, a spring lock is provided which holds the dash pot firmly.

The relay is mounted on a base which completely insulates it from the case, within which all connections are made. This case can be arranged for either open or conduit wiring.

The safety device by which the relay is tripped on removal of the cover is a flat looped spring which, when free to act, holds the contact bridge away from the contacts. When the cover is fastened in place, this spring is depressed by a pin on the cover, thus allowing the contact to be made between contacts and bridge.

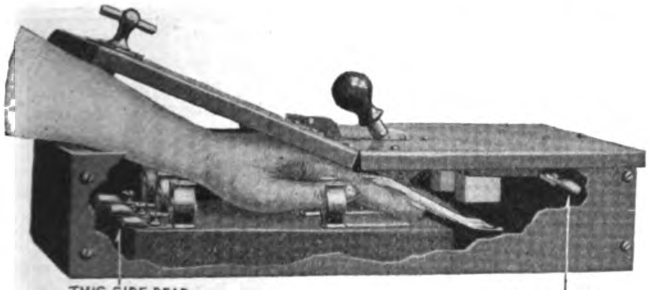
These relays are made in all commercial frequencies and voltages, and in capacities of 5 to 300 amperes.

A SAFETY SWITCH.

In many steel mills, factories, mines and similar industries where most of the workmen have little knowledge of electricity, it is desirable to use switches having no live parts exposed or accessible in the ordinary operation of the switches or when replacing fuses.

This is fully accomplished in the Krantz auto-lock switch, marketed by the Westinghouse Electric & Manufacturing Company, which is intended for use on main circuits or wherever an ordinary knife switch is applied. The switching parts and fuses are enclosed in a steel box, the cover of which is in two parts, one being screwed on to form a permanent covering for that end of the box containing the switch, and the other part being hinged so as to swing back and permit the renewal of fuses, which are located in this portion of the box. An ingenious latching mechanism makes it impossible to open the cover without first throwing the switch to the "off" position and rendering all fuses and other accessible parts dead. Thus fuses may be replaced at any time with absolute safety. As long as the door of the case is open, the switch contacts cannot be closed.

By using a padlock, the switch handle can be locked in the "off" position, making it impossible for anyone to close the switch, except the person holding the key to the padlock. By using another padlock, the cover may be locked shut, so that the fuses cannot be tampered with. Either of these padlocks can be used independently of the other, so that the switch cover can be locked shut with the switch either "on" or "off," or the switch can be locked in the "off" position with the cover either locked or open.



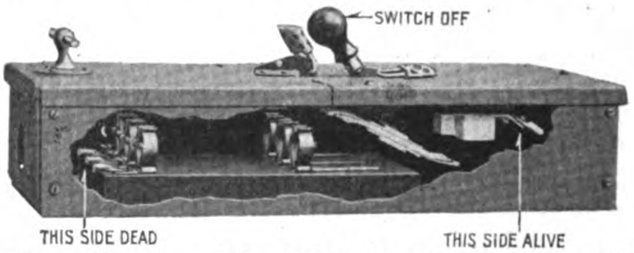
Impossible to touch live parts.

Contact is made by means of a laminated spring copper brush, double ended with auxiliary arcing contacts at each end. The outer leaves of the brush are bronze to provide additional spring pressure.

The stationary contacts are of hand-drawn copper and are mounted on slate bases, one of which in the fused switch carries one of the fuse clips, while the other forms the terminal block for the incoming line and is mounted under the stationary portion of the cover.

In clsing, the pressure between the contacts causes the laminations of the brush to spread apart, giving it a wiping or self-cleaning action.

The double-ended brushes provide a double break, dividing the arc between the two ends, each of which is provided with a separate arcing tip.



Krantz auto-lock switch, locked in open position, cover locked closed.

In the closed position the switch is held in positive contact by throwing a toggle over center. A spring provides a quick-break for opening, the mechanism being independent of the operating handle.

These switches are supplied for 250, 500 and 600-volt, for either alternating or direct-current service, and in capacities up to 2,000 amperes.

The safety features of this switch have been recognized by the American Museum of Safety, which has awarded it a gold medal and special mention.

THE TIME EFFECT IN TEMPERING STEEL.

(Continued from page 271)

In all of these experiments, the standard test specimens were prepared from the bar stock after the heat treatment. The original diameter of the stock was 1 1/32 inches. The heat treatment was carried on in large-production furnaces, temperatures being controlled with carefully standardized Wilson-Maeulen pyrometers. The reheating time was not counted for the first 20 or 30 minutes necessary for the pieces to reach furnace temperature. A reheating time of one-half hour, therefore, means at least 50 minutes in the furnace.

For quenching, a straight mineral oil was used of 0.890 specific gravity at 60 deg. F., 400 deg. F. flashpoint and 200 sec. Saybolt viscosity at 100 deg. F.

Since our measurements of strength, ductility and resilience are not absolute, and because of the inherent structural variations in steel, we cannot make exact conclusions from a few test such as are given here. From daily contact, however, we acquire knowledge of these properties which we cannot easily record, but of which we are certain. I regard this knowledge from experience the best evidence, that increasing the time of reheating increases the ductility, toughness, and machinability of the particular steels herein described, to a degree well illustrated in the above tests. The excellent physical properties that can be obtained by properly heat treating a machinery steel containing 1 to 1½ per cent manganese daoes not seem to have been generally recognized.

Trade Publications

Safety Switch Bulletin—Safety autolock switches are described and illustrated in some detail in special publication No. 1585-A, just issued by the Krantz Manufacturing Company, Inc., of Brooklyn, N. Y. These switches are designed for use on circuits wherever the ordinary knife switch may be applied. They are especially designed for safety, it being absolutely impossible to touch the live parts regardless of the position of the switch or of the door. They are particularly adapted for use in steel mills, factories, mines and other similar locations where men are employed who have no practical knowledge of electricity.

Oil Handbook—The Taylor Instrument Companies, Rochester, N. Y., has placed a book on the market entitled "Tycos Mineral Oil Tables," selling for $1, which contains over 30 tables covering temperature corrections for gravity readings, corresponding gravity and weight, and similar testing data, also for steam and refrigeration plant operation, conversion of weights, measures and moneys, etc.

Water Drinking Systems—The Armstrong Cork & Insulation Company, Pittsburgh, Pa., has issued a booklet which deals with the subject of industrial drinking water systems. Copies of the folder will be supplied upon request.

Single Rope Cable-Way Carriages—The Blaw-Knox Company, Pittsburgh, Pa., has issued a folder entitled "Blaw Automatic Single Rope Cable-Way Carriages," which we believe is self-explanatory. This carriage embodies so many advantages over any similar carriage heretofore put on the market that we believe our readers will be mightily interested in it. A copy of this folder will be forwarded to anyone upon request.

Industrial Lighting Fixtures — Ludwig Hommel & Co., Pittsburgh, Pa., has issued a booklet No. 26 called "Hommel-Lights for Industrial Lighting," showing lighting fixtures for steel plants, foundries, machine shops, mill yards, railroad yards and factory lighting of all kinds. Especially designed for use with high efficiency (nitrogen filled) lamps.

Machine Tool Drive—The Link-Belt Company, Chicago, Ill., has just issued bulletin No. 312, descriptive of silent chain drives for machine tools.

Push-Button Sockets — The Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., has just issued a four-page two-color envelope folder (publication 232) which shows several applications of C-H push-button porcelain sockets. White porcelain sockets are especially adapted for use in the bath room where the socket and fixture should be in keeping with the white porcelain and enamel ware. The folder points out the distinctive features of C-H porcelain sockets, such as the ease of installation, 660 watts capacity, and shock-proof shell. The pendant type is suited for factories, store houses and basements, and due to the push-button mechanism requires only one hand to operate.

Hand Magnet—A light weight, substantially built hand magnet, which has become extensively used by smelters and refiners, metal dealers, iron and brass foundries, machinists and others, is illustrated and described in a new leaflet (publication No. 250) just issued by the Cutler-Hammer Company, of Milwaukee, Wis. This hand magnet weighs eight pounds and has a cast aluminum covering, is operated with a simple trigger and is very useful in separating iron or steel from copper, brass, antimony, tin and other non-magnetic substances.

Traveling Grate—The Combustion Engineering Corporation, New York, has issued a new bulletin describing an interesting application of the traveling grate idea. These machines are operating, burning anthracite coal and culm at very high rating. They are also burning coke breeze in a large number of the by-product coke plants throughout the country very efficiently at considerably higher ratings than have otherwise been obtained. Recently, at a large plant operating twenty-four 1,000-hp boilers, a continuous test of 250 hours was run, using No. 3 buckwheat coal. The boilers were operated with Coxe stokers at 200 per cent of rating continuously night and day without a let-up, and for the last 10 hours the boilers were operated at 250 per cent of rating.

Fire Prevention—The National Board of Fire Underwriters, New York, has issued a book entitled "Safeguarding the Home Fire," which has already received the unqualified endorsement of many state fire marshals, insurance commissioners and other officials, and seems likely to be adopted for use as a text book by the public schools in many cities and towns.

Heat Transmission—An investigation to determine the coefficients of heat transmission of standard building materials for exterior walls has been completed by the engineering experiment station of the University of Illinois under the direction of A. C. Willard, professor of heating and ventilation, and L. C. Lichty, research fellow. The materials tested included various sizes of tile plastered, magnesia board, cork board, wood, concrete, brick, glass with and without an air space, sheet asbestos and asbestos board. The degree to which the transmission coefficients of the various materials are affected by variations in air velocity, by humidity, and by the use of air spaces in wall is discussed, and the results of the tests are given in detail in Bulletin 102. The publication is illustrated with diagrams and photographs of the apparatus. Copies of Bulletin 102 may be had gratis by addressing the Engineering Experiment Station, Urbana, Ill.

Trade Notes

At a recent meting of the Naval Consulting Board, D. W. Branton, of Colorado, was elected a member of that board.

The Westinghouse Electric & Manufacturing Company, of East Pittsburgh, Pa., has recently secured the exclusive sales agency for the United States for Frankel solderless connectors, widely used for joining electrical wires and cables. Manufacturing facilities have been increased by the Frankel Connector Company, in order to care for the new business to be secured through the Westinghouse sales organization. The Westinghouse company will also act as a distributor of Frankel testing clips.

The property and plants of the Lehigh Foundry Company and the Lehigh Car, Wheel & Axle Works, of Fullerton, Pa., have been merged into one organization, the Fuller-Lehigh Company, with its office and works at Fullerton, Pa. The properties of the two companies are adjoining and have been for a number of years under the same management. The change is one of name only. The executive personnel remains the same.

The Driver-Harris Company, Harrison, N. J., announce the election of the following officers: Frank L. Driver, president; Arlington Bensel, first vice president; Leon O. Hart, second vice president; Frank L. Driver, Jr., third vice president; Percival E. Reeves, treasurer; Stanley M. Tracy, assistant treasurer; M. C. Harris, secretary.

At the annual meeting of the stockholders and directors of the Driver-Harris Company, Harrison, N. J., Leon O. Hart was elected treasurer and a director of the company. Mr. Hart was born in Hoboken, N. J., in 1885, and was educated at the Stevens Institute of Technology, where he graduated in 1907 with the degree of mechanical engineer. After graduation he worked as a cadet engineer with the Public Service Gas Company, of Ner Jersey, for about one year. On October 2, 1908, Mr. Hart became associated with the Driver-Harris Company as electrical engineer, in which capacity he served until March, 1917, when he was elected assistant treasurer.

The Westinghouse Electric & Manufacturing Company announces the removal of its office from Phoenix, Ariz., to Tucson, Ariz. Its representatives, Messrs. J. H. Knost and W. G. Willson, will have headquarters in the Immigration Building at the latter point.

Society Meetings

The Engineers Society of Western Pennsylvania special meeting will be held in the auditorium, Union Arcade Building, Tuesday, June 4, 1918. John Johnston, secretary, National Research Council, Washington, D. C., will read a paper on the promotion of industrial research

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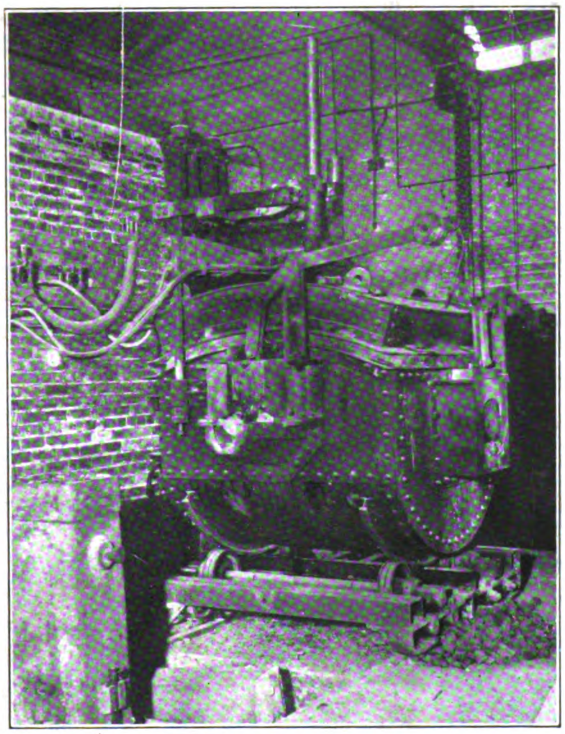

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